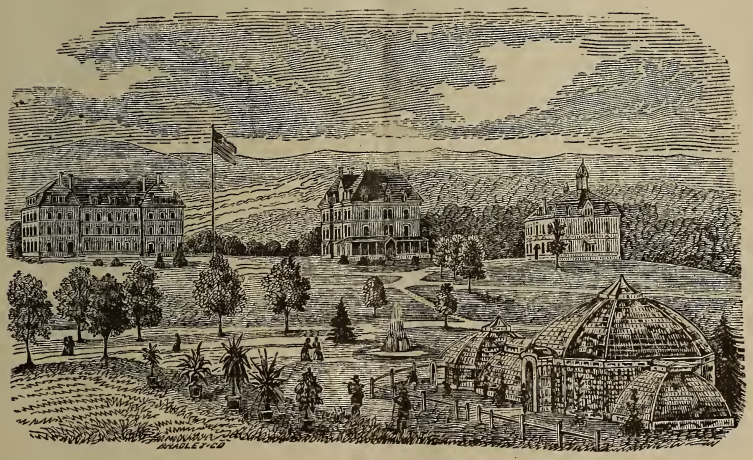
SENATE..... .....No. 100.

SIXTEENTH ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1879.



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1879.

Commonwealth of Massachusetts.

AMHERST, Jan. 30, 1879.

To His Excellency Thomas Talbot.

SIR, — I have the honor herewith to present to Your Excellency and the Honorable Council the Sixteenth Annual Report of the Massachusetts Agricultural College.

Very respectfully,

Your obedient servant,

W. S. CLARK, *President.*

Commonwealth of Massachusetts.

Executive Department,
Boston, Feb. 5, 1879.

To the Honorable the Senate.

I have the honor herewith to present for the consideration of the General Court the Sixteenth Annual Report of the Massachusetts Agricultural College.

THOMAS TALBOT.

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ANNUAL REPORT.

To His Excellency the Governor and the Honorable Council.

The Trustees of the Massachusetts Agricultural College respectfully submit their Sixteenth Annual Report.

The year 1878 has been the most successful in the history of the institution. The number of students has been very large and their conduct excellent. All the dormitory rooms have been occupied; and the boarding-house has been able to furnish satisfactory board for two dollars and a half per week. The average annual number of students for the past eleven years is one hundred and eleven, and the number last year was one hundred and sixty-two. The average yearly number of graduates during the past eight years is nineteen; but the last class numbered twenty-one. The total number of alumni is now one hundred and fifty, a catalogue of whom, with their present occupations and addresses, is appended to this report. In addition to these there have been admitted to the College three hundred and sixty-five students who have taken a partial course of less than four years, a large proportion of whom came to the institution especially for instruction in agriculture, and are now believed to be applying their knowledge of the art to practice. The total number admitted on examination or diploma since the College was opened in 1867 is six hundred and thirty-seven. Of the alumni, forty-one are now engaged in practical farming or gardening, and sixteen are indirectly connected with agricultural affairs. In general intelligence upon all matters pertaining to agriculture and horticulture, every graduate of the College will compare favorably, not only with the alumni of any other educational institution, but also with the most successful and best-informed farmers of the Commonwealth.

The Trustees believe that the theoretical and practical education afforded by the College has been equal at least to that given at any other agricultural college of the country, and that in agriculture it has fully met the requirements of the charter granted by the Legislature of 1863. In order that the public may understand the origin and objects of the College, and the obligation of the State in regard to it, the laws of the United States and of Massachusetts by which it was endowed and incorporated are herewith printed for reference, and may be found on pp. 22–26.

The following facts are worthy the consideration of every fair-minded and honorable citizen of the good old Commonwealth whose name the College bears. First, Massachusetts has accepted from the United States three hundred and sixty thousand acres of land, from the town of Amherst seventy-five thousand dollars, and from individuals a large additional sum, and entered into a formal contract with the aforesaid parties to maintain in Amherst a college which shall not be inferior in its plan of organization to the existing State institution.

Secondly, the plan of organization and course of study have been established by law, and have been found satisfactory in practice, not only at home, but in Japan, where a similar college has been organized, and is now in successful operation. Whatever has been imperfect and objectionable in the working of the College has resulted rather from the want of adequate funds than from any inherent defects of the system adopted. The great uncertainty with regard to legislative appropriations has been a constant hinderance to the judicious and economical management and development of the College; but the Trustees, with the Governor of the Commonwealth as their presiding officer, claim to have done, in the main, as well as circumstances would allow.

Thirdly, the popular sentiment in favor of agricultural education and of scientific inquiry for the improvement of farming has steadily increased since the College was opened. This is demonstrated by the fact that more than four hundred young men applied for information about the College in the months of July and August last; and one-quarter of them appeared for admission to the freshmen class, while the majority of the others were deterred only by want of means to

defray the expenses of the course. This result of offering free tuition refutes completely the assertion that there is no demand for agricultural education. If the college were properly supported, and thrown open, without charge for tuition, to the young men of Massachusetts, it would be crowded with superior students, and become exceedingly popular.

Fourthly, the military department of the College, — required, officered, and equipped by the General Government, — not only affords admirable facilities for valuable discipline to every student, but also educates, far more thoroughly than any militia system can, a large number of young men to serve as officers or soldiers in case of need. This feature of the course of study and training is far more important than is generally supposed and has from the first received most careful attention, and been eminently successful. No wiser expenditure for military purposes can be made by the State than to grant the small sum needed for the proper maintenance of the College.

Fifthly, the College has been and should be an experimental station for the trial and investigation of whatever promises to be of value in agriculture. The hearty recognition of the value of the scientific work done in years past by the faculty and students of the institution, by the lamented Agassiz and other scientists, has been a source of great encouragement to the president and professors, who have patiently endured much abuse from the newspapers, especially those of the cities.

Sixthly, the members of the Board of Agriculture are overseers of the College, and by their examining committees have regularly visited it, and reported upon its condition, adding such friendly criticism as they thought might be useful. The Trustees have endeavored, so far as their means would allow, to be guided by the suggestions offered. They have honestly and courageously striven to render the institution worthy the name given it by the Legislature of 1863, and, notwithstanding the unpopularity of the word "agricultural," they have not asked to have it stricken out, as has been done in Ohio[1] and Pennsylvania. They believe the

[1] The Ohio Agricultural and Mechanical College has been organized and re-organized by the Legislature four times; and in 1878 it was named the Ohio State University, and graduated its first class of six. It has real estate and appliances worth half a million dollars, and a cash income from the State treasury of thirty thousand dollars.

most difficult portion of the task assigned them has been accomplished, and that the College, substantially in its present form, is worthy of confidence and support, and that the people will not allow it to be reduced to insignificance for want of a small amount of money.

Seventhly, the financial condition of the College demands immediate attention and wise action on the part of the Legislature. Year after year the annual deficit has been reported, and repeated petitions for needed appropriations have been made. The committee on agriculture have granted hearings, and visited the College, and always reported favorably; but the handful of farmers, even when well informed themselves, have often been unable to secure the passage of their bill. The debt, to the accumulation of which no Legislature has objected, now amounts to thirty-two thousand dollars, and should be paid as soon as practicable. The Trustees, as unpaid agents of the Commonwealth, have done the best they could to carry on the College according to the plan prescribed by the statutes; and, when the necessary funds were not furnished them, they have been compelled to borrow the required amount. It would have been both unwise and unlawful for them to have modified the system of education without the approval of the Legislature. If, after due consideration, the General Court shall decide that the College is better than Massachusetts can afford to maintain for the education of her sons, then a new institution upon an inferior plan should be organized. A reference to the summary statement of all expenditures on account of the College, which may be found on p. 108, shows that the total cost of this grand experiment in agricultural education and improvement has been not less than one million dollars. More than one-quarter of this sum has been invested in land, buildings, apparatus, furniture, live-stock, and other appliances for the use of the several departments of the College. The Agricultural Fund in the State treasury, the income of which is applied for the payment of salaries, is two hundred and forty thousand dollars. In addition to this there are in the College treasury ten thousand dollars, constituting the Hills Fund (given by Messrs. L. M. and H. F. Hills), the Grinnell Prize Fund of one thousand dollars (the gift of Hon. William Claflin), and the Mary Robinson Scholarship Fund, of the

same amount. A bequest of one thousand dollars has been made by Mr. Whiting Street of Northampton, who died during the past year; but the money has not yet been received by the treasurer. Thus it appears that the present resources of the College amount to half a million dollars, and that a cash income of not less than thirteen thousand dollars may be relied upon, without any regard to the receipts from tuition, room-rent, or sales of produce or live-stock.

Although every other State in the Union offers free tuition to its students in agriculture, the Trustees of the Massachusetts College have felt obliged in years past to charge seventy-five dollars per annum for tuition only, or three hundred dollars for the full course. This sum, added to the cost of room-rent, uniform, books, and board, was more than the farmers have felt able or willing to pay, especially during a period of financial depression. As the number of students consequently was diminished, the opponents of the institution loudly proclaimed that the experiment was a failure, and that there was no demand for agricultural education. With a view of testing this matter, the Trustees voted to establish a free scholarship in each of the eleven congressional districts of the State, and also to allow each of the alumni to nominate one student for a free scholarship for four years, provided he should enter the freshman class of 1878. The result has already been mentioned, and demonstrates the fact that the number of students would be limited only by the capacity of the buildings, if the College were placed in the same relation to the public as the State normal schools, the high schools, and the other agricultural colleges of the country.

The good name and the best interests of the Commonwealth imperatively require that the results of sixteen years of hard labor and large expense in organizing the College, now in successful operation, should receive candid and intelligent consideration from the Legislature. Certainly the wealthiest State in the Union cannot plead inability as an excuse for violating a plain contract to maintain "at least one such college" as is described in the first section of the act of incorporation. The Legislature of 1863 formally accepted the offer of the United States, with all its conditions, and then instructed the Trustees to demand seventy-five

thousand dollars as the price of the advantages to be derived from the location and perpetual maintenance of such a college in any town which would also furnish a suitable farm for a reasonable sum. Amherst was one of four towns to bid for the institution, and was selected by the Trustees, with the approval of the Governor and Council, as, on the whole, offering the most eligible site and the most favorable conditions. She paid her money on demand, and now very properly expects Massachusetts to fulfil her part of the agreement. Again: the Trustees established eleven free congressional scholarships in January last, and gave due information of the same to the Legislature in their Fifteenth Annual Report. No objection having been made to their mode of carrying on the College by any Legislature, they deemed it for the best good of all concerned to offer to the alumni additional scholarships as before mentioned. There are consequently now about one hundred students at the College who have been promised free tuition for four years by the accredited agents of the State. It is clearly impossible to carry out this contract in its letter and spirit without the favorable action of the Legislature.

In view of the foregoing statements, the Trustees respectfully ask that a thorough inspection of the College be undertaken by the joint committees on education, agriculture, and military affairs, or by a special committee, and that such provision be made for the payment of the existing debt, and the future maintenance of the institution, as, after due consideration, may be deemed wise. They further recommend that the College be required to give free tuition to students from Massachusetts, as they believe its usefulness would be largely increased, and its standard of discipline and scholarship elevated, by such a policy. They also express the opinion that ample funds for the maintenance of the College may be secured, without any increase of taxation, by a careful re-adjustment of the usual appropriations for agricultural improvements.

THE MASSACHUSETTS EXPERIMENTAL STATION.

Notwithstanding the want of both time and money for such purposes, the faculty of the College have in years past undertaken a great variety of important investigations, and,

as required by the statute, have published many of them in the annual reports. Aside from the valuable educational work of the officers, there can be no doubt that the experiments upon the production of sugar and sirup from the beet-root and from sorghum, the annual inspection of all commercial fertilizers sold in the State, the introduction of special manures for special crops, and the scientific inquiries in regard to the circulation of sap, the phenomena of plant-growth, the temperature of the soil, and the relations of the moisture in the air and the earth to fertilization, have been of more direct pecuniary value to the citizens of the Commonwealth than the entire cost of the College up to this time. And yet these admirable results are but indications of the far grander and more useful possibilities which might be achieved with suitable appliances and encouragement.

Professor Levi Stockbridge, in January of last year, generously offered the sum of one thousand dollars to defray the necessary expenses, for one season, of an experimental station at the College, provided the Trustees would authorize its establishment. Accordingly, President Clark, Professor Stockbridge, Professor Goessmann, Secretary Flint, and Honorable Richard Goodman were appointed a committee, with full power to act as the managers of the station. They soon after held a meeting, and, after discussion, assigned subjects for investigation to different members, and appropriated the money to defray the cost of apparatus and necessary assistance. The results of the year's labors, so far as prepared for publication, are appended to this report, and are both interesting and instructive.

Professor Stockbridge has constructed a lysimeter and much other ingenious apparatus, and made an immense number of observations upon a variety of subjects connected with the fall of rain and dew, the temperature of different soils at all hours of the day and night, and the effects of various fertilizers upon the soil and upon each other. His report will be found to contain many new facts of vast importance both to the science and the art of agriculture.

Dr. Goessmann's report on the Early Amber cane, a variety of sorghum produced in Minnesota, seems to show conclusively that it cannot be profitably cultivated in Massachusetts for the production of dry sugar, though the yield and

quality of the sirup are quite satisfactory. The experiment was carried out upon an extensive scale, at an expense of more than five hundred dollars. About twenty different fields were planted in Amherst and neighboring towns, and more than two thousand gallons of sirup were made at the mill on the College farm. After four years of laborious and intelligent trial, it is clearly demonstrated that the sugar-beet is the most desirable crop which can now be introduced into Massachusetts, whether for the economical production of sugar, or for the improvement of agriculture. Perhaps the experiments which are in progress in Maine under the patronage of the State may show the possibility of developing this industry without the investment of large sums of money in building sugar-factories, which is the only hinderance to its immediate introduction into the Connecticut Valley. The sugar-beet now furnishes more than thirty per cent of the sugar of the world, and is the most profitable crop of France and Germany, which raise, not only the sugar they consume, but also a large quantity for exportation.

It is certainly to be hoped, in the interests of scientific agriculture, that the liberality and enterprise of Professor Stockbridge in thus starting the Massachusetts Experimental Station will be followed up by the appropriation or gift of means for its continuance.

THE FARM.

Superintendent Southwick has attended faithfully to his duties in the care of the live-stock and the general management of the farm. He has done some important work in draining wet places, and in breaking up several acres of new land west of the Colleges. His crops have, in the main, been good. Besides the usual large yield of hay, he has harvested twenty-six hundred bushels of ears of excellent corn, three hundred and fifty-six bushels of mixed wheat and oats, and two hundred and seventy-five bushels of rye.

The neat-stock consists of twenty-three thorough-bred Short-horns, twenty-one Ayrshires, six Jerseys, and two Brittanies. Besides these, there are also on the farm five horses and twenty-five very fine Berkshire swine. Notwithstanding the extremely low price of pork and live pigs, the receipts from sales during the year amounted to five hundred and

twenty-eight dollars. The swine have been kept in fine condition at a mere nominal cost in pasture. During the winter the neat-cattle, which are in excellent condition and of superior quality, are fed once a day on cooked fodder, at a cost of three cents for each animal. Corn-stover and poor hay are cut and steamed in a covered box with a mixture of ground rye, oats, and corn on the cob; and this feed has proved to be both palatable and nutritious, as well as economical.

THE HORTICULTURAL DEPARTMENT.

Professor Maynard and Superintendent Clark have successfully managed the plant-houses, the nurseries, the orchards, the vineyard, and the plantations of small-fruits. The strawberry-crop amounted to twenty-five hundred baskets, and a larger number of vegetable and bedding plants were sold than ever before; the total receipts of the department amounting to a little over sixteen hundred dollars. The peach-orchard is in good condition; but the crop of fruit was destroyed by the warm weather of December, 1877. The fruit-buds at present are sound and promising. The vineyard produced but few grapes, and those mostly of poor quality, in consequence, largely, of mildew. The apple and pear trees are healthy, but not old enough to yield much fruit. Three thousand European larch and five thousand white-ash seedlings have been cultivated in the nursery, and are to be set next spring upon two acres of land which has been prepared for them. The following list shows the number of certain valuable fruit and ornamental trees and shrubs added to the stock during the year 1878: —

Apple-seedlings root grafted	9,150
Pear-seedlings budded	1,200
Plum-seedlings budded	500
Peach-seedlings budded	300
Quince-stocks budded with pear	800
Orange-quince grafted on apple-roots	600
Grape-vines from cuttings	4,200
Evergreens, mostly Japanese, from cuttings	10,000
Umbrella pine (*Sciadopitys verticillata*)	3,000
Katsura (*Cercidiphyllum Japonicum*)	200
Japanese maple in twenty-three varieties.	

In addition to these, a large number of all the more desira-

ble species of ornamental shrubs, and many herbaceous perennials, have been propagated; and two thousand hills of the best varieties of blackberries and raspberries will come into bearing next summer.

A very interesting collection of fifty species of grass and forage plants has been raised from seeds presented by J. M. Thorburn & Co. of New-York City.

Col. Eliphalet Stone of Dedham kindly sent to the College scions of four very promising seedling pears originated by him.

Valuable collections of the woods of the United States and of Brazil have been received for the botanic museum from the Department of Agriculture at Washington, and numerous species of seeds, woods, and other specimens from Japan, through the favor of Professor D. P. Penhallow of the Sapporo Agricultural College.

ANNIVERSARY EXERCISES.

The Farnsworth Prize Declamations occurred as usual in Amherst-College Hall, on Monday evening, June 17. The gold medals were awarded to William Gilbert Lee of the sophomore class, and Charles Rudolph of the freshman class; and the silver medals, to Alvan Luther Fowler, sophomore, and Charles Louis Flint, jun., freshman.

The Totten Military Prize was awarded to Charles Francis Coburn, who read his essay on "The American Military Problem" to a large and interested audience in the College Chapel, on Wednesday, June 19, after the usual drill and review on the parade. Mr. Coburn also had the honor of being selected as the orator to represent the College at the commencement exercises of Boston University on the 9th of June.

The Hills Botanical Prizes were awarded to Willie Levi Boutwell, who had the best general herbarium and the best collection of woods, and received twenty dollars; and to Horace Edward Stockbridge, who received ten dollars for the second best herbarium.

The competition for the Grinnell Agricultural Prizes was unusually sharp, and showed that the honor and the money were highly appreciated by the contestants. The following account of the examination is taken from "The Journal

of Chemistry," and was written by Dr. James R. Nichols, chairman of the examining committee appointed by the board of overseers, and an acknowledged authority in scientific agriculture: —

"It became our duty as well as our pleasure to be present at the examinations of some of the classes at our State Agricultural College, at the annual commencement in June. The senior class, in the examination for the Grinnell Prizes, fell under our special supervision, and a very thorough examination resulted. Messrs. O. B. Hadwen of Worcester and W. L. Warner of Sunderland were associated with us on the committee, both gentlemen of culture, and practical men on the farm. The first prize, of fifty dollars, was awarded to C. F. Coburn of Lowell; and the second, of thirty dollars, to H. E. Stockbridge of Amherst, son of Professor Stockbridge of the College. These young men, together with the class of about twenty, sustained an examination, continued through three hours, on a wide variety of topics. We were desirous, independent of the matter of the prizes, of ascertaining what the young men had actually acquired at the College which fitted them for the practical duties of the farm. Here were twenty students before us who had completed the course of study as set down in the college curriculum; and an opportunity was afforded for obtaining some knowledge of the extent and value of their acquisition as students of agriculture. The practical nature of the examination is shown by a glance at the topics considered, — 'Origin and Composition of Soils;' 'Implements of Tillage;' 'Plants, their Composition, and Sources from which the Material is obtained;' 'The Susceptibility of the Plant to Modification and Improvement by Cultivation;' 'Changes produced in Soil by the Growth of Plants;' 'Methods by which the Fertility of the Soil may be retained, or Exhausted Soils restored;' 'Grain-Growing, its Influence on the Fertility of the Farm, and how retaining in its Culture;' 'Root-Crops;' 'Hay and Grass Crops;' 'Fruit-Culture on the Farm;' 'Stock-Husbandry, and the Adaptations of the United States to this Industry;' and, 'Breeds of Cattle.'

"It is true, a class examination, however fair and above-board it may be, is not an infallible test of the positive attainments of students in any branch of education: still, any one with a clear comprehension of the nature of the topics introduced, and possessing ordinary sagacity, can judge quite satisfactorily and justly of the value of the instruction imparted.

"We say unhesitatingly that the young men acquitted themselves exceedingly well, and no one of them appeared incompetent for taking charge of a farm, and conducting its affairs in accordance with good sense and advanced knowledge of husbandry. They had evidently been well drilled in the 'science of agriculture,' and the drill embraced the various departments which closely and remotely relate to the interests of the farm. Each of the young men was required to write upon a practical topic, without text-books, or any aid except what his own knowledge supplied; and thus above twenty essays were placed in the hands of the com-

mittee for examination. This was an important test of scholarship, and supplied a clew to the general training or culture of the students at the College. Some of their papers were brief and unimportant; but others were quite extended and able essays, worthy even of publication. We are pleased to be able to bear testimony to the good appearance of the graduating class at Amherst. How much influence the graduates will exert in the direction of improving our farms and our stock it is impossible to decide, as it is not known how many will put in practicé the facts and principles in agriculture acquired at the College. It is certainly of some importance to turn out upon the world twenty young men apparently so well qualified for the successful prosecution of the arts of husbandry."

The anniversary exercises of the eighth graduation day were held in Amherst-College Hall on Wednesday afternoon. The theses were of superior quality, and well delivered, the valedictory addresses being spoken by Arthur Amber Brigham. The diplomas of the university were presented by President Clark; while the college diplomas, with the signature of the Governor of the Commonwealth, were bestowed upon the members of the graduating class by the Hon. Marshall P. Wilder, who spoke as follows: —

"Friends and Fellow-Citizens, — Called on, as I am, unexpectedly, to perform the duties of his Excellency the Governor, whose absence we so much regret, my words will be brief. I desire, however, to offer you my hearty congratulations on the prosperity of our College, and especially on the noble representation of young gentlemen who appear before you to receive the degrees to which they are so justly entitled.

"Nothing has given me more pleasure than the very creditable manner in which they have acquitted themselves to-day; and I am quite sure, whether they are to become farmers, professional men, or tradesmen, they will ever be grateful for the education which they have here received, and of which they have given such substantial evidences to-day.

"Few things have given me more pleasure than the fact that this College has sent forth so many young men who have been ornaments to society, and blessings to our land. Especially have I been gratified that the Government of Japan, after surveying the continent of Europe, should have selected our beloved president to build and put in operation the first agricultural college in those far-off isles, and to have installed in office as its president and faculty young gentlemen who were graduates of the Massachusetts Agricultural College.

"Gentlemen of the Graduating Class, — By virtue of authority committed to me, I hereby admit you to the degree of Bachelor of Science, to all the honors, rights, and privileges of graduates of the Massachusetts Agricultural College.

"In testimony whereof I now deliver to each of your number a diploma, duly signed by the president of the faculty, and by his Excellency the Governor of the Commonwealth.

"And now may you go forth, animated and inspired by a spirit of noble manhood and Christian principle, to share in the responsibilities and rewards of well-spent lives, — go forth valiant and stout-hearted, as messengers of peace and plenty, not to enrich the earth by human blood, but to make it yield more and more abundantly, ever remembering that the highest triumph of civilization is the conquest of mind over matter, the dominion of man over Nature, improving, adorning, and elevating her to the noblest purposes of creation. Thus will you honor our College, shine as stars in the crown of our good old Commonwealth, and become benefactors in our land.

"God bless you in your going out! God bless us all in our endeavors to promote the welfare of our race! God bless this institution in the future as in the past, and make it an honor to the State and country, a power in our land, and a blessing to the millions that are to follow us!"

Respectfully submitted,

By order of the Trustees,

W. S. CLARK,

President.

Amherst, Jan. 30, 1879.

AN ACT

DONATING PUBLIC LANDS TO THE SEVERAL STATES AND TERRITORIES WHICH MAY PROVIDE COLLEGES FOR THE BENEFIT OF AGRICULTURE AND THE MECHANIC ARTS.

Be it enacted by the Senate and House of Representatives of the United States of America, in Congress assembled, —

That there be granted to the several States, for the purposes hereinafter mentioned, an amount of public land, to be apportioned to each State, a quantity equal to thirty thousand acres for each senator and representative in Congress, to which the States are respectively entitled by the apportionment under the census of eighteen hundred and sixty, *provided* that no mineral lands shall be selected or rchased under the provisions of this act.

SECT. 2. *And be it further enacted*, That the land aforesaid, after being surveyed, shall be apportioned to the several States in sections, or subdivisions of sections not less than one-quarter of a section ; and, whenever there are public lands in a State subject to sale at private entry at one dollar and twenty-five cents per acre, the quantity to which said State shall be entitled shall be selected from such lands within the limits of such State. And the Secretary of the Interior is hereby directed to issue to each of the States in which there is not the quantity of public lands subject to sale at private entry at one dollar and twenty-five cents per acre, to which said State may be entitled under the provisions of this act, land-scrip to the amount in acres for the deficiency of its distributive share ; said scrip to be sold by said States, and the proceeds thereof applied to the uses and purposes prescribed in this act, and for no other use or purpose whatsoever : *provided*, that in no case shall any State to which land-scrip may thus be issued be allowed to locate the same within the limits of any other State, or of any Territory of the United States ; but their assignees may thus locate said land-scrip upon any of the unappropriated lands of the United States, subject to sale at private entry at one dollar and twenty-five cents or less per acre : *and provided further*, that not more than one million acres shall be located by such assignees in any one of the States : *and provided further*, that no such location shall be made before one year from the passage of this act.

SECT. 3. *And be it further enacted*, That all the expenses of management, superintendence, and taxes, from date of selection of such lands, previous to their sales, and all expenses incurred in the management and disbursements of the moneys which may be received therefrom, shall be paid by the States to which they may belong out of the treasury of said States, so that the entire proceeds of the sale of said lands shall be applied, without any diminution whatever, to the purposes hereinafter mentioned.

SECT. 4. *And be it further enacted*, That all moneys derived from the sale of the lands aforesaid by the States to which the lands are apportioned, and from the sales of land-scrip hereinbefore provided for, shall be invested in stocks of the United States, or of the States, or some other safe stocks yielding not less than five per centum upon the par value of said stocks; and that the moneys so invested shall constitute a perpetual fund, the capital of which shall remain forever undiminished (except so far as may be provided in section fifth of this act), and the interest of which shall be inviolably appropriated by each State which may take and claim the benefit of this act, to the endowment, support, and maintenance of at least one college, where the leading object shall be — without excluding other scientific and classical studies, and including military tactics — to teach such branches of learning as are related to agriculture and the mechanic arts, in such manner as the Legislatures of the States may respectively prescribe in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life.

SECT. 5. *And be it further enacted*, That the grant of land, and land-scrip hereby authorized, shall be made on the following conditions, to which, as well as to the provisions hereinbefore contained, the previous assent of the several States shall be signified by legislative acts.

First, If any portion of the fund invested, as provided by the foregoing section, or any portion of the interest thereon, shall by any action or contingency be diminished or lost, it shall be replaced by the State to which it belongs, so that the capital of the fund shall remain forever undiminished; and the annual interest shall be regularly applied without diminution to the purposes mentioned in the fourth section of this act, except that a sum not exceeding ten per centum upon the amount received by any State under the provisions of this act may be expended for the purchase of lands for sites or experimental farms, whenever authorized by the respective Legislatures of said States.

Second, No portion of said fund, nor the interest thereon, shall be applied directly or indirectly, under any pretence whatever, to the purchase, erection, preservation, or repair of any building or buildings.

Third, Any State which may take and claim the benefit of the provisions of this act shall provide, within five years, at least not less than one college, as described in the fourth section of this act, or the grant to such State shall cease: and said State shall be bound to pay the United States the amount received of any lands previously sold, and that the title to purchasers under the State shall be valid.

Fourth, An annual report shall be made regarding the progress of each college, recording any improvements and experiments made, with their cost and results, and such other matters, including State industrial and economical statistics, as may be supposed useful; one copy of which shall be transmitted by mail free, by each, to all other colleges which may be endowed under the provisions of this act, and also one copy to the Secretary of the Interior.

Fifth, When lands shall be selected from those which have been raised to double the minimum price, in consequence of railroad grants, they shall be computed to the States at the maximum price, and the number of acres proportionally diminished.

Sixth, No State, while in a condition of rebellion or insurrection against the Government of the United States, shall be entitled to the benefit of this act.

Seventh, No State shall be entitled to the benefits of this act unless it shall express its acceptance thereof by its Legislature within two years from the date of its approval by the President.

Sect. 6. *And be it further enacted*, That land-scrip issued under the provisions of this act shall not be subject to location until after the first day of January, one thousand eight hundred and sixty-three.

Sect. 7. *And be it further enacted*, That the land officers shall receive the same fees for locating land-scrip issued under the provisions of this act as is now allowed for the location of military bounty land warrants under existing laws, *provided* their maximum compensation shall not be thereby increased.

Sect. 8. *And be it further enacted*, That the governors of the several States to which scrip shall be issued under this act shall be required to report annually to Congress all sales made of such scrip until the whole shall be disposed of, the amount received for the same, and what appropriation has been made of the proceeds.

Approved July 2, 1862.

An Act to incorporate the Trustees of the Massachusetts Agricultural College.

Be it enacted by the Senate and House of Representatives in General Court Assembled, and by the authority of the same, as follows: —

Section 1. Marshall P. Wilder of Dorchester, Charles G. Davis of Plymouth, Nathan Durfee of Fall River, John Brooks of Princeton, Henry Colt of Pittsfield, William S. Southworth of Lowell, Charles C. Sewall of Medfield, Paoli Lathrop of South Hadley, Phinehas Stedman of Chicopee, Allen W. Dodge of Hamilton, George Marston of Barnstable, William B. Washburn of Greenfield, Henry L. Whiting of Tisbury, John B. King of Nantucket, their associates and successors, are hereby constituted a body corporate, by the name of the Trustees of the Massachusetts Agricultural College, the leading object of which shall be, without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life, to be located as hereinafter provided; and they and their successors, and such as shall be duly elected members of said corporation, shall be and remain a body corporate by that name forever. And, for the orderly conducting of the business of said corporation, the said trustees shall have power and authority from time to time, as occasion may require, to elect a president, vice-president, secretary, and treasurer, and such other officers of said corporation as may be found necessary, and to declare the duties and tenures of their respective offices; and also to remove any trustee from the same corporation, when, in their judgment, he

shall be rendered incapable, by age or otherwise, of discharging the duties of his office, or shall neglect or refuse to perform the same; and, whenever vacancies shall occur in the Board of Trustees, the Legislature shall fill the same: *provided, nevertheless*, that the number of members shall never be greater than fourteen, exclusive of the Governor of the Commonwealth, the Secretary of the Board of Education, the Secretary of the Board of Agriculture, and the President of the Faculty, each of whom shall be, *ex officio*, a member of said corporation.

Sect. 2. The said corporation shall have full power and authority to determine at what times and places their meetings shall be holden, and the manner of notifying the trustees to convene at such meetings; and also, from time to time, to elect a president of said college, and such professors, tutors, instructors, and other officers of said college, as they shall judge most for the interest thereof, and to determine the duties, salaries, emoluments, responsiblities, and tenures of their several offices. And the said corporation are further empowered to purchase or erect, and keep in repair, such houses and other buildings as they shall judge necessary for the said college; and also to make and ordain, as occasion may require, reasonable rules, orders, and by-laws not repugnant to the Constitution and laws of this Commonwealth, with reasonable penalties, for the good government of the said college and for the regulation of their own body, and also to determine and regulate the course of instruction in said college, and to confer such appropriate degrees as they may determine and prescribe; *provided, nevertheless*, that no corporate business shall be transacted at any meeting unless one-half at least of the trustees are present.

Sect 3. The said corporation may have a common seal, which they may alter or renew at their pleasure; and all deeds sealed with the seal of said corporation, and signed by their order, shall, when made in their corporate name, be considered in law as the deeds of said corporation; and said corporation may sue and be sued in all actions, real, personal, or mixed, and may prosecute the same to final judgment and execution, by the name of the Trustees of the Massachusetts Agricultural College; and said corporation shall be capable of taking and holding in fee simple, or any less estate, by gift, grant, bequest, devise, or otherwise, any lands, tenements, or other estate, real or personal: *provided* that the clear annual income of the same shall not exceed thirty thousand dollars.

Sect. 4. The clear rents and profits of all the estate, real and personal, of which the said corporation shall be seized and possessed, shall be appropriated to the uses of said college in such manner as shall most effectually promote the objects declared in the first section of this act, and as may be recommended from time to time by the said corporation, they conforming to the will of any donor or donors in the application of any estate which may be given, devised, or bequeathed, for any particular object connected with the college.

Sect. 5. The Legislature of this Commonwealth may grant any further powers to, or alter, limit, annul, or restrain, any of the powers vested by this act in, the said corporation, as shall be found necessary to promote the best interests of the said college; and more especially may appoint and establish overseers or visitors of the said college, with all necessary

powers for the better aid, preservation, and government thereof. The said corporation shall make an annual report of its condition, financial and otherwise, to the Legislature at the commencement of its session.

SECT. 6. The Board of Trustees shall determine the location of said college in some suitable place within the limits of this Commonwealth, and shall purchase, or obtain by gift, grant, or otherwise, in connection therewith, a tract of land containing at least one hundred acres, to be used as an experimental farm, or otherwise, so as best to promote the objects of the institution; and, in establishing the by-laws and regulations of said college, they shall make such provision for the manual labor of the students on said farm as they may deem just and reasonable. The location, plan of organization, government, and course of study, prescribed for the college, shall be subject to the approval of the Legislature.

SECT. 7. One-tenth part of all the moneys which may be received by the State treasurer from the sale of land-scrip, by virtue of the provisions of the one hundred and thirtieth chapter of the acts of the thirty-seventh Congress, at the second session thereof, approved July second, eighteen hundred and sixty-two, and of the laws of this Commonwealth, shall be paid to said college, and appropriated towards the purchase of said site or farm, *provided*, *nevertheless*, that the said college shall first secure, by valid subscriptions or otherwise, the further sum of seventy-five thousand dollars, for the purpose of erecting suitable buildings thereon; and, upon satisfactory evidence that this proviso has been complied with, the governor is authorized from time to time to draw his warrants therefor.

SECT. 8. When the said college shall have been duly organized, located, and established, as and for the purposes specified in this act, there shall be appropriated and paid to its treasurer each year, on the warrant of the governor, two-thirds of the annual interest or income which may be received from the fund created under and by virtue of the act of Congress named in the seventh section of this act and the laws of this Commonwealth, accepting the provisions thereof, and relating to the same.

SECT. 9. In the event of a dissolution of said corporation by its voluntary act at any time, the real and personal property belonging to the corporation shall revert and belong to the Commonwealth, to be held by the same, and be disposed of as it may see fit, in the advancement of education in agriculture and the mechanic arts. The Legislature shall have authority at any time to withhold the portion of the interest or income from said fund provided in this act, whenever the corporation shall cease or fail to maintain a college within the provisions and spirit of this act and the before-mentioned act of Congress, or for any cause which they deem sufficient.

Approved April 29, 1863.

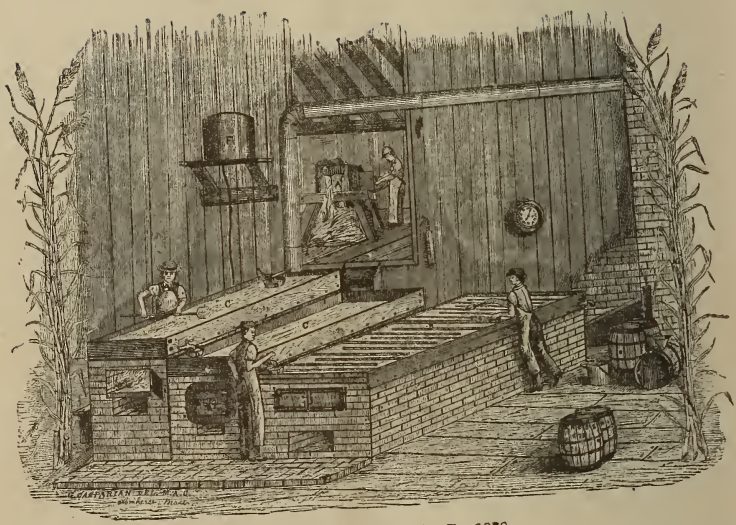
REPORT TO THE DIRECTORS

OF THE

MASSACHUSETTS EXPERIMENTAL STATION.

BY

PROFESSOR C. A. GOESSMANN.



SORGHUM-MILL, M. A. C., 1878.

A, Victor Crushing-Mill. B, Cook's Evaporator. C, C, Sheet-iron Pans. D, D, D, Strainers. E, Metallic Pipe conducting Juice from Mill to Pan. F, Water-Tank.

REPORT ON EARLY AMBER CANE.

The unusual interest which of late the Minnesota Early Amber Cane has awakened in some of the Western States, as a plant qualified for the production of sirup and sugar for the general market, induced President Clark to make arrangements for the purpose of ascertaining the value of this particular kind of sorghum upon the soil of Massachusetts. The seeds which served for the trial were secured through the department of agriculture at Washington, D.C., to obtain the genuine article. Somewhat more than twenty acres were planted in our vicinity during the past season, from one-fourth of an acre to one acre of cane being raised by each party. The experimental field upon the College-grounds contained just one acre. The apparatus used for crushing and pressing the cane, and the pan for evaporating the juice, were the same as those extensively used in Minnesota, — a Victor Mill and a Cook's Evaporator, both of the size recommended by the patentees for the working of the produce from twenty acres of cane. The entire management of the practical part of the experiment was, for obvious reasons, confined to the selection of such modes of operation as could be carried on by any intelligent farmer with a moderate outlay of money. The kind information received from Mr. S. H. Kinney of Morristown, Rice County, Minn., one of the foremost successful experimenters with the Early Amber Cane, regarding the current practice among his acquaintances, served as a guide in the cultivation of the cane and the working of its juice. To the writer was assigned the task of studying the changes which the cane undergoes during the later period of its growth, in order to learn the time when the sugar becomes more prominent in its juice, to ascertain the rate at which its percentage increases,

and to determine the particular point in the ripening process of the plant when the largest amount of sugar is present, and to notice, finally, the changes which the cane subsequently suffers in regard to the quantity and quality of its saccharine matter. Having studied in previous years, soon after its first introduction into the agricultural interests of the country, the Chinese sugar-cane for a similar purpose,[1] I propose to introduce into the following discussion such facts established on that occcasion as may aid in a due understanding of the questions involved.

The origin of the Early Amber Cane on trial is described by the commissioner of statistics of Minnesota, in his report for 1877, p. 38, in the following words: "After the close of the war two men, strangers to each other, whose homes were twenty miles apart (Messrs. Seth H. Kinney of Morristown, and Charles F. Miller of Dundas, Rice County), in the heart of that immense forest known as the 'Big Woods' of Minnesota, struggled, with a tenacity and persistence that excited the mournful pity of their neighbors, to successfully manufacture molasses from the sorghum, or Chinese sugar-cane. One of these men (Miller) chanced upon the seed of a hybrid, an acclimated species of the cane, known as the 'Minnesota Early Amber,' which, by some inspiration, he was induced to send to a friend in Missouri, with directions to plant it there, and return to him the ripened seed. From the first crop produced by that seed he was able to manufacture a sirup that was so immeasurably superior to his former productions, that he was assured of complete success. After that, the difficulties were of detail, some of them almost insurmountable from lack of means, and others were equally so from the very simplicity of them, and their remedies. Either of these men might have succeeded alone; but when they came together, as they did at last, and combined their experience, and their resources of skill and invention, a new industry was born, and a new factor in the wealth and the commerce of this State will very soon command public attention." In connection with these introductory remarks are also published letters of Messrs. Miller and Kinney to the

[1] See Transactions of the New-York State Agricultural Society of 1861, vol. xxi. pp. 787–811: Contribution to the Knowledge of the Nature of the Chinese Sugar-cane, *Sorghum saccharatum* (W.), by C. A. Goessmann.

commissioner, containing an interesting and somewhat detailed account of their mode of cultivating and harvesting the cane, and of securing and working its juice into sirup and sugar, besides a description of the actual results obtained, as well as the prospects held out for future enterprise by the introduction of improved systems of treatment, based on a better knowledge of the subject in its scientific and industrial relations.

As the Early Amber Cane raised upon the College-grounds has furnished almost exclusively the material for my investigation, previous to the harvesting of the cane from the experimental fields on other farms in the Connecticut Valley, I begin my report with a short statement from Professor Stockbridge, concerning the course pursued in the cultivation of the field under his immediate charge. The land engaged in the experiment was one acre in extent, and consisted of a heavy sandy loam. Part of it had been used previously for the raising of garden-vegetables. It was fertilized at an early date in the spring with chemicals at a cost of fifteen dollars. The fertilizer contained potash, phosphoric acid, and nitrogen, in proportions favorable for the formation of sugar in the crop. The seed was planted on the 18th of May, in drills three feet and a half apart, with the plants about five inches distant from each other in the drill. The field was four times cultivated, and the harvesting began on the 14th of September, and closed on the 22d. The crop when fully grown was from eleven to twelve feet high, with canes unusually vigorous and handsome, resembling in general appearance rather those of the broom-corn than those of the sorghum of an earlier day.

The examination of the cane was carried out in the following manner. On the dates specified the stalks were cut off six inches above the ground; and two feet in length of the tops, and all the leaves, were removed. The remaining part of the cane was subsequently crushed and pressed to secure its juice. The latter — after being tested for its specific gravity by Brix's saccharometer, and for its relative amount of free acid at boiling heat by means of a solution of carbonate of soda, containing one gramme of sodium carbonate anhydride in a hundred cc. of distilled water — was treated without delay with a solution of basic acetate of lead to secure

a good defecation, in the same manner as is usual in the case of the juice of the sugar-beet root. The filtered juice was subsequently divided, in every instance, into two portions, one of which was tested directly in the usual manner, with Fehling's solution, for grape-sugar; and the other, after being treated in the customary way with hydrochloric acid at a moderate heat, to convert the cane-sugar present into glucose, was treated like the former portion for the total amount of sugar. The difference noticed between the two tests was calculated, according to well-known rules, as cane-sugar.

It has been the aim during the entire investigation to secure in all cases, not otherwise specified, a comparative value to the various analytical statements.

I. — Examination of the Early Amber Cane raised upon the College Farm.

1.

1878.

Aug. 15. — Juice obtained from plants *five* feet high; no flower-stalks in sight. Specific gravity, 4.2° Brix, at 27° C. temperature. Grape-sugar present, 2.48 per cent. Cane-sugar present, none. Standard soda solution required, 6.8 cc. The microscope revealed the presence of many granules of starch. Cane lost at 100° to 110° C., 92.07 per cent moisture. Cane left at 100° to 110° C., 7.93 per cent solid matter.

2.

Aug. 16. — Juice obtained from plants *ten* feet high; no flower-stalks in sight. Specific gravity, 5.8° Brix, at 24° C. temperature. Grape-sugar present, 4.06 per cent. Cane-sugar present, none. Soda solution required, 9 cc. Cane lost at 100° to 110° C., 88.90 per cent moisture. Cane left at 100° to 110° C., 11.10 per cent solid matter.

3.

Aug. 20. — Juice obtained from plants with the lower leaves of the canes turned reddish; flower-stalks well developed; flowers, however, not yet open. Specific gravity, 7.9° Brix, at 24° C. temperature. Grape-sugar present, 3.47 per cent. Cane-sugar present, 2.15 per cent. Soda solution required, 7 cc. Cane lost at 100° to 110° C., 87 per cent moisture. Cane left at 100° to 110° C., 13 per cent solid matter.

4.

Aug. 24. — Juice from plants bearing flower-stalks with fully developed open flowers. Specific gravity, 8.7° Brix, at 23° C. temperature. Grape-sugar present, 3.7 per cent. Cane-sugar present, 3.per cent. Soda solution required, 4 cc. Cane lost at 100° to 110° C., 85.93 per cent moisture. Cane left at 100° to 110° C., 14.07 per cent solid matter.

5.

Aug. 27. — Juice from canes of plants in full blossom. Specific gravity, 10.0° Brix, at 25° C. temperature. Grape-sugar present, 3.65 per cent. Cane-sugar present, 4.13 per cent. Soda solution required, 10 cc. Cane lost at 100° to 110° C., 84.52 per cent moisture. Cane left at 100° to 110° C., 15.48 per cent solid matter.

6.

Aug. 30. — Juice from canes of plants with the formation of the seed fairly begun. Specific gravity, 9.50° Brix, at 30° C. temperature. Grape-sugar present, 4 per cent. Cane-sugar present, 3.81 per cent. Soda solution required, 9.5 cc. Cane lost at 100° to 110° C., 83.86 per cent moisture. Cane left at 100° to 110° C., 16.14 per cent solid matter.

7.

Sept. 2. — Juice from canes of plants with seeds in the milk, i.e., seeds of full size, yet still soft. Specific gravity, 10.70° Brix, at 27° C. temperature. Grape-sugar present, 3.85 per cent. Cane-sugar present, 4.41 per cent. Soda solution required, 9.5 cc. Cane lost at 100° to 110° C., 84.15 per cent moisture. Cane left at 100° to 110° C., 15.85 per cent solid matter.

8.

Sept 9. — Juice from canes of plants with seeds still soft. Specific gravity, 12.10° Brix, at 22° C. temperature. Grape-sugar present, 3.21 per cent. Cane-sugar present, 6.86 per cent. Soda solution required, 9.5 cc. Cane lost at 100° to 110° C., 73.87 per cent moisture. Cane left at 100° to 110° C., 26.13 per cent solid matter.

9.

Sept. 9. — Juice from canes of plants from which, on the 2d of September, the leaves and the tops had been removed, without disturbing them otherwise. Specific gravity, 12.8° Brix, at 22° C. temperature. Grape-sugar present, 3.77 per cent. Cane-sugar present, 6.81 per cent. Soda solution required, 9.5 cc. Cane lost at 100° to 110° C., 73.25 per cent moisture. Cane left at 100° to 110° C., 26.75 per cent solid matter.

10.

Sept. 18. — Juice from canes of plants left upon the field without any alteration regarding leaves or tops. Specific gravity, 13.2° Brix, at 22° C. temperature. Grape-sugar present, 3.57 per cent. Cane-sugar present, 7.65 per cent.

11.

Sept. 18. — Juice from canes of plants from which only the tops had been removed, leaving the remaining portion undisturbed in the soil. Specific gravity, 13.8° Brix, at 22° C. temperature. Grape-sugar present, 3.16 per cent. Cane-sugar present, 8.49 per cent.

12.

Sept. 18. — Juice from canes of plants from which the tops and all the leaves had been removed on the 9th of September, whilst the remaining portion was not disturbed in the soil until cut on the 18th of September. Specific gravity, 11.5° Brix, at 22° C. temperature. Grape-sugar present, 3.16 per cent. Cane-sugar present, 5.85 per cent.

13.

Sept. 18. — Juice from canes of plants which were cut off on the 9th of September, had their tops removed as usual, yet their leaves left on, and subsequently left upon the field for *nine* days, before the sample tested was secured by pressing. Specific gravity, 12.8° Brix, at 22 C. temperature. Grape-sugar present, 10 per cent. Cane-sugar present, .60 per cent.

14.

Sept. 21. — The juice secured from the cane of No. 13 on the 21st of September showed specific gravity, 13° Brix, at 21° C. temperature, and, when taken still two days later, its specific gravity was equal to 15° Brix, at 18° C. temperature.

From the previously-stated observations we may safely deduce the following conclusions regarding the questions above specified, at least, as far as the conditions of our soil and climate bear on the growth and development of the Minnesota Early Amber Cane as a sugar-producing plant: —

1. The grape-sugar appears in the cane at an early stage of its growth (Nos. 1 and 2), and increases slowly to from three to four per cent before cane-sugar is formed.

2. The cane-sugar is first noticeable at the time when the flower-stalks become visible above the leaves; and its amount

increases steadily until the seeds are of full size, yet still soft (Nos. 3–8).

3. The relative proportion of grape-sugar to cane-sugar did not exceed, at any time before the hardening of the seeds, 3.16 per cent of the former to 8.49 per cent of the latter: in the majority of cases it was about three to seven.

4. The cane loses a considerable amount of its moisture during the period of the development of the seeds, from ten to twelve per cent (see Nos. 7 and 8), aiding thereby in increasing the density of the juice: the better quality of the latter during later periods in the life of the plant has, for this reason, to be ascribed largely to that cause, and not to the continued formation of sugar. The quality of the juice is improved at that stage, largely, therefore, if not entirely, at the expense of its quantity.

5. The increase in the density of the juice of the cane after the seeds are full grown may be somewhat retarded by taking off the leaves, without disturbing the remaining plant in the soil (No. 12).

6. The cane-sugar of the plants changes gradually yet steadily into grape-sugar, after they are once cut off. The degree of that change varies widely, and depends largely on their exposure, being more serious during moist and warm than in dry and cold weather.

7. The safest way to secure the full benefit of the Early Amber Cane crop for sirup and sugar manufacture is to begin cutting the canes when the seed is full grown, yet still soft (in our case between the 10th and 15th of September), and to grind them without delay.

The grinding of the cane raised upon the College farm began on the 15th of September. As quite a difference of opinion prevailed among the cultivators of the Early Amber Cane, according to advice received from well-informed parties in Minnesota, regarding the most appropriate time for cutting the cane, — some maintaining that it should not be cut until the mill was ready to grind it without delay; while others claimed to have obtained the best results after keeping the cut cane for a week or more spread upon the ground, before carrying it to the mill for grinding, — a part of our cane, after being cut, was left upon the field for about ten days (see experiments Nos. 10–13) before being ground and pressed:

the remainder was cut, and without delay sent to the mill. The examination of the juice obtained from both of these lots of cane gave the results which are stated above in experiments Nos. 10–13. They admit of no other explanation, but that the best course to pursue consists in grinding the matured cane as soon as it is cut.

The juice coming from the mill was carried through an iron pipe to a metal sieve to remove the suspended particles of cane, and thence into a sheet-iron pan of seventy to eighty gallons' capacity, for defecation. Following the practice of Messrs. Kinney and Miller, for some time nothing was added to the juice to assist in the defecation. Towards the close of the season, when the coagulation of the albuminoids was less thorough, a small amount of slaked lime was added, avoiding, however, an excess of lime; for the re-action of the latter on the grape-sugar present would tend to increase the color, and to affect at the same time the taste unpleasantly. The efficient use of boneblack filters for the removal of both objectionable results was, for economical reasons, out of the question. The copious scum produced by the heating of the fresh juice to from 85° to 95° C. in the defecating pan was removed as much as possible by skimming, and subsequent filtering through a woollen cloth filter on its passage into a second iron pan, where the heating was continued. From this second pan the hot, defecated juice was drawn, as required, into a Cook's evaporator, constructed of copper, where the skimming process was continued until the sirup had reached the desired density, which, as a general rule, was equal to 75° of Brix's saccharometer when hot. The color of the sirup thus produced from recently-cut cane was yellowish; its taste, as might be expected without the use of boneblack, was somewhat peculiar, yet pleasant, and quite generally liked. The average yield amounted to from a hundred and sixty to a hundred and seventy gallons per acre. To study the effect of the mode of manufacture pursued, on the composition of the sirup, the following experiment was instituted. The juice of a healthy, fresh-cut cane was tested before it passed into the defecator, and also, subsequently, the sirup obtained from it.

Sept. 29. — Juice, 14.7° Brix, at 15° C. temperature. Grape-sugar present, 3.61 per cent. Cane-sugar present, 8.16 per cent.

The sirup obtained from the previously-stated juice contained
Grape-sugar, 37.87 per cent; cane-sugar, 37.48 per cent.

A glance at these results shows that the relative proportion of the cane-sugar and the grape-sugar, as found in the juice, is seriously altered in the course adopted for its manufacture into sirup. In sight of these facts, it will be quite generally conceded that the sugar-production from sirup like the above must remain a mere incidental feature in the Amber Cane industry in our section of the country, as long as the cost of separating the sugar does not offer more substantial advantages.

II.—Examination of the Early Amber Cane raised by Farmers in the Vicinity of the College.

As soon as the crop of the College had been disposed of, the canes from outside experimental fields were treated in a like manner. The interest in our experiments taken by farmers generally began soon to make itself felt at the mill by the arrivals of lots of cane from all sides, rendering it necessary to increase the working force. The mill, being worked by three horses, was run day and night, and the evaporators were thus supplied with juice without any serious interruption, except the short time required for cleaning. The management of the mill, and the manufacture of the sirup during the entire season (from the 15th of September to the 25th of October), were very efficiently superintended by Messrs. Atherton Clark and H. E. Stockbridge, both graduates of the College, and special students of chemistry in the post-graduate course. Mr. E. B. Bragg of the class of 1875 also rendered valuable assistance in the chemical examination of the juices.

Some of the cane sent on was ground soon after it had been cut: other lots had been cut weeks before their turn in the mill came round. In some instances the yield of sirup per acre exceeded two hundred gallons, — one instance being reported where it amounted to two hundred and fifty-four gallons per acre, — in others, it fell behind the average, on account of the exposure the canes had suffered before being ground. No systematic examination of the juice of the cane coming from outside fields was attempted, partly on account

of the absence of such facts as impart special value to the tests caried out, partly on account of want of time to follow up each case in a satisfactory manner. A general examination of the juice worked on each day was, however, continued; and, as the results obtained in this connection are not entirely without interest regarding some points involved in our inquiry, I enter them on record.

Sept. 25. — The cane, after being cut, left for three weeks upon the field, during dry warm weather. Juice, 19.8° Brix, at 21 C. temperature. Grape-sugar present, 11.91 per cent. Cane-sugar present, 6.27 per cent.

Sept. 26. — Juice, 14.7° Brix, at 15° C. temperature.

Sept. 28. — Juice, 17.8° Brix, at 12° C. temperature. Grape-sugar present, 16.6 per cent. Cane-sugar, not determined.

Oct. 1. — Juice, 17.5° Brix, at 19° C. temperature.

Oct. 3. — Juice, 15° Brix, at 22° C. temperature.

Oct. 4. — Juice, 16.1° Brix, at 17° C. temperature. Grape-sugar present, 8.62 per cent. Cane-sugar present, 6.16 per cent. Soda solution required, 12 cc.

Oct. 7. — Cane cut just before grinding, and sent with its leaves through the mill. Juice, 16.7° Brix, at 20° C. temperature. Grape-sugar present, 4.16 per cent. Cane-sugar present, 9.94 per cent. Soda solution required, 6.8 cc.

Oct. 8. — Cane cut fresh the day before grinding; the leaves had, however, been taken off the canes two weeks before cutting them. Juice, 12.8° Brix, at 17° C. temperature. Grape-sugar present, 5.16 per cent. Cane-sugar, present, 5.27 per cent. Soda solution required, 7 cc.

Oct. 9. — Juice, 18.4° Brix, at 17° C. temperature. Grape-sugar present, 7.57 per cent. Cane-sugar, not determined. Soda solution required, 10.6 cc.

Oct. 10. — Cane cut five days before grinding. Juice, 15.2° Brix, at 15° C. temperature.

Oct. 11. — Cane having been kept two weeks at the mill. Juice, 17.1° Brix, at 16° C. temperature.

Oct. 14. — Cane several weeks old when ground. Juice, 18.2° Brix, at 15° C. temperature. Grape-sugar present, 10.42 per cent. Cane-sugar, not determined. Soda solution required, 10.4 cc.

Oct. 15. — Juice, 15.2° Brix, at 18° C. temperature.

Oct. 16. — Juice, 17.3° Brix, at 22° C. temperature.

Oct. 17. — Juice, 18° Brix, at 20° C. temperature.

Oct. 18. — Juice, 15.1° Brix, at 23° C. temperature. Grape-sugar present, 7.57 per cent. Cane-sugar, not determined.

Oct. 19. — Juice, 15.5° Brix, at 15° C. temperature. Grape-sugar present, 9.22 per cent. Cane-sugar, not determined. Soda solution required, 13.6 cc.

Oct. 20. — Juice, 17.3° Brix, at 15° C. temperature.
Oct. 22. — Juice, 16.2° Brix, at 16° C. temperature. Grape-sugar present, 8.3 per cent. Cane-sugar, not determined.
Oct. 23. — Juice, 18.3° Brix, at 17° C. temperature. Grape-sugar present, 11.3 per cent. Cane-sugar present, 5.5 per cent. Soda solution required, 14 cc.
Oct. 24. — Juice, 16.6° Brix, at 15° C. temperature. Grape-sugar present, 8.63 per cent. Cane-sugar, not determined. Soda solution required, 9 cc.

The above-stated observations lead, on the whole, to the same conclusions as those arrived at in connection with the examination of the cane from the College-field. The relative proportion between grape-sugar and cane-sugar noticed in the cane from the College-grounds has in no instance been changed for the better. The injurious changes which the cane undergoes after being once cut off are rendered quite conspicuous. A trial to decide whether it would be better economy to grind the cane after its leaves have been removed, as has been the rule, or to send it with its leaves through the mill, demonstrated the fact that the saving of labor in the field by omitting the stripping does not compensate for the loss suffered in the clogging of the mill, and the waste of juice, which occurs when the leaves are left on.

III. — Valuation of the Crop raised on the College-Grounds.

The expenses incurred in the cultivation and harvesting of one acre of the Early Amber Cane upon the College-grounds have been as follows: —

Cost of chemicals used as fertilizers	$15 00
tillage	19 00
cutting cane, stripping leaves, cutting tops, and carting to mill	16 00
	$50 00

The crop produced has yielded one hundred and sixty-four gallons of a good sirup, about forty bushels of seed of a middling quality, besides from four to five tons of moist *bagasse*, and from one ton to one ton and a half of semi-dry leaves. The sirup has been partly sold in retail, at fifty

cents per gallon, to visitors at the sugar-mill. The seed has been estimated by Professor Stockbridge to be equal to about forty bushels, and is considered worth, for feeding purposes, thirty-five cents per bushel, or fourteen dollars for the entire yield. The *bagasse* is known to be suitable for paper manufacture, and is supposed to bring about five dollars; whilst the leaves, even for fertilizing purposes, cannot be considered worth less than from three to four dollars.

The manufacturing expenses of the sirup have been higher than they would have been in case of a more permanent arrangement for manufacturing purposes, where steam or water power would be used as motive power instead of horses. Judging from the results obtained under similar conditions elsewhere, it seems quite safe to assume that the cost would not exceed from twelve to thirteen cents per gallon, or about one-half of what it actually amounted to in our experiments. Comparing, on the basis of the previously-adopted values, the expenses and the returns per acre of our trial with the Early Amber Cane, we find, —

Expenses equal to	$70 00
Returns equal to	105 00
Leaving thus a surplus of	$35 00

I need not, however, to add that these results may be materially improved by a larger yield of sirup, which is fully within reach; for in two instances it rose up to two hundred and forty gallons per acre. Every additional fifty gallons of sirup would be equal to from six to seven dollars increased cash return.

The Western cultivators of the Early Amber Cane claim for it in two important points a superiority over the Chinese sorghum of twenty years ago: —

1. It ripens earlier, and offers thereby a better chance to raise it on an extensive scale, with less risk of having the crop partly destroyed by frost.

2. Its juice furnishes a better sirup, which proves its better fitness for that purpose.

It remains a matter of regret that no systematic chemical examination into the changes which this variety of cane undergoes during its growth and its period of ripening in Minnesota has been made; since the exact period of the

maturity of a plant, as well as the particular amount of its constituents, as sugar, starch, &c., are known to be not unfrequently greatly affected by climate, and by the condition and peculiar adaptation of the soil turned to account for its cultivation.

It remains for me merely to state that our results are not as satisfactory as we hoped for when entering on the experiment. By pursuing a course of treatment based on strictly scientific principles, without reference to cost, I succeeded many years ago in securing between eight and nine per cent of cane-sugar from the juice of the Chinese sorghum: others have since obtained similar results.

The presence of a large amount of grape-sugar in all the later stages of the Early Amber, as well as of all other varieties of this species, is a serious feature in the composition of the juice, impairing greatly the chances for a copious separation of the cane-sugar by simple modes of treatment. The necessity of applying more costly apparatus, and engaging skilled labor to secure the larger portion of the cane-sugar, if once conceded, places the production of dry sugar from sorghum beyond the scope of general farm enterprise.

REPORT TO THE DIRECTORS

OF THE

MASSACHUSETTS EXPERIMENTAL STATION.

BY

PROFESSOR LEVI STOCKBRIDGE.

REPORT.

The undersigned, upon whom, by your vote, was devolved the duty of conducting experiments on the deportment of soils towards water and various manures by the use of the lysimeter, has performed that duty with as much care and accuracy as the time and means at his disposal would allow, and is able to submit the following results: —

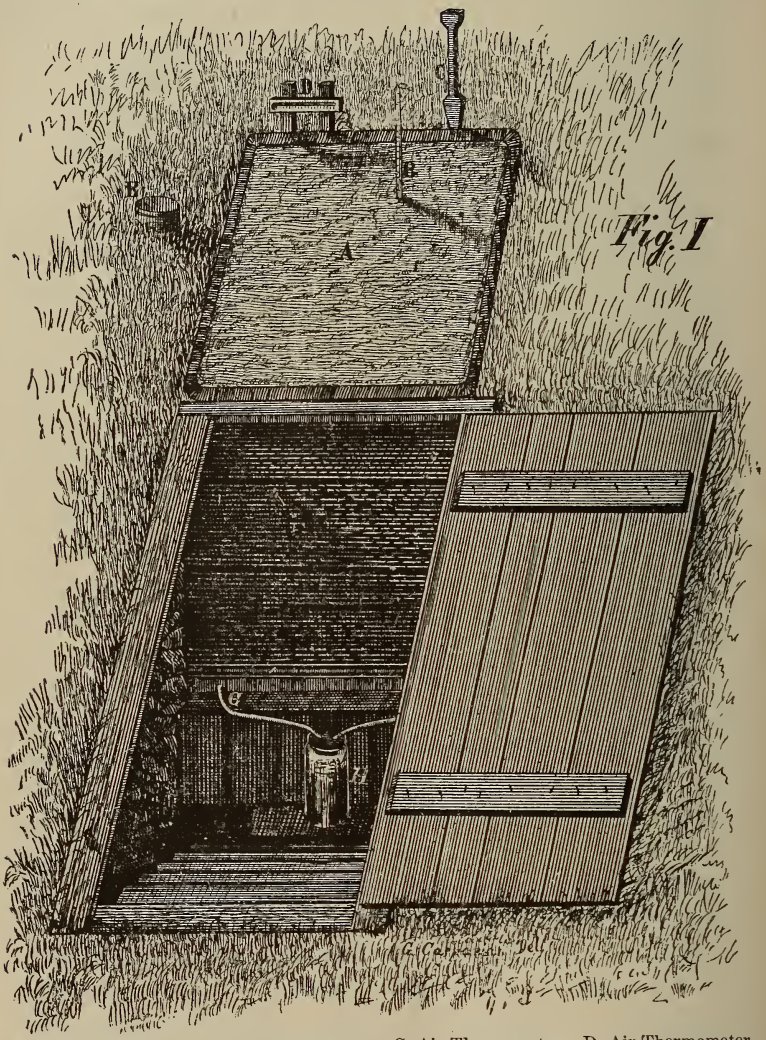
Method of constructing the Lysimeter.

Though not found in dictionaries or encyclopædias, the word "lysimeter" means simply an instrument for measuring the natural percolation of rain falling upon the soil. At the time the experiment was instituted, it was quite difficult to obtain definite information as to its proper mode of construction and use. There was but one such instrument in America, and that not thoroughly constructed nor fully equipped. The instrument, such as it was, was on the farm of the Sturtevant Brothers of South Framingham, Mass., who had kept a record of its operations for two years. A visit was made those gentlemen, who kindly showed me the instrument, and its method of operation; and from one of them, Dr. E. Lewis Sturtevant, a paper was received making invaluable suggestions in relation to the details of construction and equipment, and the direction of investigations considered of the greatest importance. From the information here obtained, and in view of the small appropriation for the purpose, it was deemed advisable to confine the experiments to one variety of soil, and to a medium depth; and the lysimeter was accordingly constructed as follows: A box was made of two-inch chestnut plank, three feet deep, 45.726 inches square on the inside, and which would enclose $\frac{1}{3000}$ of an acre of land to the depth of the box. The planks on

the sides were grooved and tongued, dovetailed at the corners, and firmly spiked together. The box was painted inside and out with coal-tar, and lined on the inside with sheet-copper, which was doubled over the upper and lower edges of the box, and securely tacked on the outside. The bottom was made of the same material, put together in the same manner, painted and lined with the same, but was made six inches larger than the square of the box. One end of the bottom was scarfed to an edge to facilitate its passage through the soil when driven under the box, and in the other two one-inch holes were bored in the centre of the end of the plank diagonally upward to and through the copper lining of the box. Into these holes, copper tubes were inserted, which on the inside were soldered water-tight to the lining of the bottom, and which protruded one inch and a half from the end of the plank to carry off the percolating water. The soil selected to experiment upon was a *drift* which had been in grass nine years without manure. The first ten inches on the surface was a chocolate-colored sandy loam, in which were many pebbles and small round stones; the next fourteen inches consisted of a light yellow gravelly loam, and the fourteen inches at the bottom was made up of smooth round stones from pebble-size to six inches in diameter, the interspaces being filled with sand and gravel. The whole depth was thirty-eight inches, and it would be called a very "leachy" soil. The box was filled with this earth, without materially disturbing it, by placing it, without the bottom, on the turf, and digging a wide space on the outside, to the depth of a few inches below the edge, and then driving it down with a heavy timber. Care was taken not to dig under its edge, but to make it cut its way as it was driven, and thus to fill perfectly. In this manner it was settled to the required depth, or until its upper edge was even with the surrounding turf. Owing to the nature of the subsoil, the putting under of the bottom was attended with the greatest difficulty, but was accomplished by making a strong timber frame, square, but two inches larger on the inside than the box. This was dropped down over it to the gravel, into which it was sunk until its upper surface was two inches below the lower edge of the box. The scarfed end of the bottom was then placed on this frame under the

box, and then, with two jack-screws on the back side to hold the box and its contained earth in place, and two in front operating against the end of the bottom, it was forced into its proper position. The copper lining of the bottom, and that of the box which turned under the lower edge, was then soldered together, so that there could be no escape of water. The whole apparatus was set with an incline of one inch to the front to carry the water to the percolating tubes, and to hold which a glass jar was procured containing one gallon, but scaled on its side in ounces and pints. To prevent evaporation from this jar, it was fitted with a large stopper, through which were two orifices, into which were inserted rubber pipes connected with the copper tubes as conductors of the percolating water. It was finished by throwing back and tamping in the earth which had been excavated on three sides, and building walls on the fourth, from the bottom to the surface of the ground, and enclosing sufficient space for the collecting jar and a flight of stairs for the accommodation of the attendant, which was covered with a frame and door for the protection of the jar and tubes, but with an incline to carry rain from the space. A rain-gauge of the same dimensions and scale as that used at the Smithsonian Institution was placed by the side of the lysimeter, the size of the latter being such that one inch of rainfall deposited in it 9.05 gallons of water, which would be equivalent to 27,150 gallons or 848.43 barrels per acre. For recording the temperature two Fahrenheit thermometers were used having corresponding scales. The one for recording the air temperature was hung on a scalloped board, with the bulb two inches above the soil, its stem, but not its bulb, receiving the direct rays of the sun. The one in the soil had a bulb one inch in length, which through the season was kept buried one-half an inch below the surface, and its lower end was generally or always in moist soil; and in the following records this depth is the point indicated in temperature of surface soil. After all the appliances were completed, the soil within the box was turned over to the depth of seven inches, and it has been hoed and kept clear of vegetation through the season, which fact should be borne in mind, as affecting its temperature by day and night as well as the percolation. The record of the rainfall and percolation was

commenced May 1, and will be continued through the year, but, for the purposes of this report, is brought only to Nov. 30. Owing to delay caused by difficulty in obtaining correct and agreeing thermometers, the record of temperature



A, Soil in Lysimeter. B, Soil Thermometer. C, Air Thermometer. D, Air Thermometer. E, Rain Gauge. F, Front of Lysimeter Box. G. Rubber Pipes to conduct Water from Tubes to Jar. H, Water Jar.

could not be commenced until May 23, and was closed for the year Nov. 30.

Plate No. 1 represents the lysimeter with the door of the jar-room open, and with its different appliances and instruments.

RAINFALL. — *The number of days on which rain fell between May 1 and Dec. 1 was sixty-two. The daily fall, the total for each month, and for the entire period, were as follows: —*

Month and Day.	Rainfall in Inches.	Month and Day.	Rainfall in Inches.	Month and Day.	Rainfall in Inches.	Month and Day.	Rainfall in Inches.	Month and Day.	Rainfall in Inches.	Month and Day.	Rainfall in Inches.	Month and Day.	Rainfall in Inches.	RÉSUMÉ.	
														Month.	Rainfall.
May 4	.14 inch.	June 4	.02 inch.	July 4	.06 inch.	Aug. 1	.17 inch.	Sept. 1	.29 inch.	Oct. 7	.06 inch.	Nov. 12	.13 inch.	May	2.14 inch.
" 5	.72 "	" 8	1.95 "	" 8	.02 "	" 6	.38 "	" 2	.33 "	" 9	.51 "	" 18	2.47 "	June	5.88 "
" 10	.35 "	" 10	.09 "	" 9	.22 "	" 7	1.36 "	" 3	.12 "	" 19	.25 "	" 20	.18 "	July	3.52 "
" 11	.11 "	" 11	.17 "	" 10	.47 "	" 9	.45 "	" 5	.44 "	" 23	.52 "	" 22	.84 "	Aug.	4.45 "
" 21	.26 "	" 12	.26 "	" 12	.10 "	" 11	.56 "	" 6	.14 "	" 28	.30 "	" 23	.25 "	Sept.	2.09 "
" 26	.11 "	" 17	.10 "	" 18	.09 "	" 13	.15 "	" 12	.15 "	" 30	.31 "	" 25	.11 "	Oct.	2.38 "
" 30	.29 "	" 22	1.47 "	" 21	1.05 "	" 16	.26 "	" 13	.13 "	" 31	.03 "	" 27	1.43 "	Nov.	5.24 "
" 31	.16 "	" 23	.88 "	" 27	.32 "	" 17	.32 "	" 21	.10 "	–	–	" 28	2.03 "	–	–
–	–	" 24	.05 "	" 30	1.19 "	" 21	.19 "	" 26	.39 "	–	–	–	–	–	–
–	–	" 25	.11 "	–	–	" 25	.61 "	–	–	–	–	–	–	–	–
–	–	" 27	.78 "	–	–	–	–	–	–	–	–	–	–	–	–
Total	2.14 inches	Total	5.88 inches	Total	3.52 inches	Total	4.45 inches	Total	2.09 inches	Total	2.38 inches	Total	5.24 inches	Total	25.70 inch.

Each inch of rainfall deposited 9.05 gallons of water in the lysimeter. Total water received in the seven months was 222.585 gallons, which was equal to 697,755 gallons, or 22,150.95 barrels, per acre.

PERCOLATION. — *The number of days in which the percolation was sufficient to require the emptying of the jar was thirty-seven. The days of the month, the total for each month, and for the entire period, were as follows: —*

Month and Day.	Percolation. Pints.	Ounces.	Month and Day.	Percolation. Pints.	Ounces.	Month and Day.	Percolation. Pints.	Ounces.	Month and Day.	Percolation. Pints.	Ounces.	Month and Day.	Percolation. Pints.	Ounces.	Month and Day.	Percolation. Pints.	Ounces.	Month and Day.	Percolation. Pints.	Ounces.
May 5	4	0	June 9	5	0	July	0	0	Aug. 7	16	0	Sept. 6	5	0	October	0	0	Nov. 18	8	0
" 6	14	0	" 10	9	13	–	–	–	" 8	8	0	" 7	5	0	–	–	–	" 19	15	4
" 9	2	2	" 11	6	0	–	–	–	" 9	8	0	" 10	1	6	–	–	–	" 20	7	8
" 14	1	10	" 12	6	14	–	–	–	" 10	8	0	–	–	–	–	–	–	" 21	7	0
–	–	–	" 13	6	8	–	–	–	" 11	5	8	–	–	–	–	–	–	" 22	16	0
–	–	–	" 18	5	4	–	–	–	" 12	8	0	–	–	–	–	–	–	" 23	24	0
–	–	–	" 22	8	0	–	–	–	" 19	8	0	–	–	–	–	–	–	" 24	14	0
–	–	–	" 23	42	14	–	–	–	" 28	0	4	–	–	–	–	–	–	" 25	6	2
–	–	–	" 24	8	0	–	–	–	–	–	–	–	–	–	–	–	–	" 27	32	0
–	–	–	" 26	1	4	–	–	–	–	–	–	–	–	–	–	–	–	" 28	33	4
–	–	–	" 28	6	10	–	–	–	–	–	–	–	–	–	–	–	–	" 29	8	2
Total	21	12	Total	106	3	Total	0	0	Total	61	12	Total	11	6	Total	0	0	Total	171	4

Recapitulation.		
Month.	Percolation. Pints.	Ounces.
May	21	12
June	106	3
July	0	0
August	61	12
September	11	6
October	0	0
November	171	4
–	–	–
–	–	–
–	–	–
–	–	–
Total for 7 months	372	5

The percolation for the entire period, reduced to gallons, was 46,543, or 4,432.38 barrels per acre; the rainfall for the same time, as previously given, amounted to 22,150.95 barrels. The average daily evaporation from this soil for seven days, from June 27 to July 4, was 164 barrels per acre. This must be considerable more than the daily average for the season; but it may be safe to say, that, deducting the sixty-two days on which rain fell, the evaporation was a hundred barrels daily, or 15,100 barrels for the season. The percolation and evaporation, then, amounted to 19,532.38 barrels, showing that on Dec. 1 this surface-soil, to the depth of three feet, was holding 2,618.57 barrels of water per acre.

REPORT ON THE PERCOLATED WATERS OF THE LYSIMETER.

BY PROFESSOR C. A. GOESSMANN.

The samples of water received from the lysimeter at different times amounted, in most instances, to from twelve to fourteen pounds of the liquid. An equal volume of the percolated water was used in the various tests, to impart to them an approximate comparative value. The examination was of a qualitative character, as directed, and, as a general rule, only with reference to the presence or absence of the chemicals previously applied to the soil. In no case was a new application of chemicals made until the percolation of the water of the previous rainfall had ceased. The sample of water which passed through the lysimeter (May 12, 1878) soon after its construction, and before any chemicals were applied, contained the usual constituents of drainage-waters coming from an unfertilized drift-soil characteristic of our section of the State; viz., a considerable amount of carbonate of lime, smaller portions of the carbonates of iron and magnesia, besides not unfrequently traces of potassium oxide and nitric acid. The entire amount of the mineral constituents, and of the carbonate of lime in particular, was somewhat larger than may be noticed in ordinary cases. The exceptional condition of the first sample of drainage is most likely due to an unavoidable partial disturbance of the soil in the lysimeter, incidental to its construction, which, in turn, must have favored the disintegrating atmospheric agencies.

I. — The soil of the lysimeter was dressed in the customary way with muriate of potash, containing eighty per cent of chloride of potassium, at the rate of two hundred and fifty pounds per acre. This operation was carried out on the 17th of May: the percolation of rain-water began on the 9th of June. The percolated water contained .0076 per cent of chlorine, and but .00017 per cent of potassium oxide. Allowing .000128 of the chlorine for the formation of potassium chloride, there remains .00747 per cent of the chlorine in excess, which proved to be present in combination with lime as chloride of calcium. Taking into calculation that the first sample of water which passed through the original soil contained a noticeable amount of potassium oxide, it is quite safe to assume that the soil retained practically the entire amount of potassium which had been added to it in the form of muriate of potash, whilst the chlorine thereby liberated, after entering into combination with an equivalent amount of lime in the soil, appears in the percolated water as chloride of calcium. The results obtained in this experiment correspond well with those of earlier investigations regarding the action of the chloride of potassium on soils containing lime and magnesia; they furnish also a good illustration of the fact that both the removal of crops and the peculiar forms of the fertilizing materials used for their growth may modify, independent of each other, more or less seriously, the composition of the soil left behind.

II. — The soil was dressed on the 20th of June with six hundred pounds of sulphate of ammonia per acre, the salt containing twenty-four per cent ammonia. The water began to flow on the 23d of June. One part of it was acidulated with sulphuric acid before being carefully evaporated to dryness, to retain the ammonia, if present. A careful test established the absence of ammonia in the residue. The second half of the water was rendered alkaline by means of carbonate of soda, previous to its evaporation, to prevent the loss of nitric acid in particular. The saline matter thus secured contained a trace of nitric acid. Whether the presence of this acid under existing circumstances can be ascribed to an oxidation of some of the ammonia applied is somewhat doubtful, considering the short time of exposure; yet it is by

no means impossible, judging from the observations of Tuttle and others.

III. — Superphosphate of lime, at the rate of two hundred and fifty pounds per acre, and containing fifteen per cent of soluble phosphoric acid, was incorporated into the soil of the lysimeter on the 6th of July. The percolation of the rain-water began Aug. 7. From thirteen to fourteen pounds of that liquid were evaporated to dryness. The saline matter left behind was dissolved in some diluted nitric acid, and subsequently tested for phosphoric acid, by means of molybdate of ammonia: no trace of that acid could be discovered. The soil had retained the entire amount of phosphoric acid used in the experiment.

IV. — Nitrate of soda, containing sixteen per cent of nitrogen, was applied as a final dressing of the lysimeter soil on the 24th of August, at the rate of six hundred pounds per acre. The percolated water was secured the first week of September. The residue left after its careful evaporation contained a considerable quantity, comparatively speaking, of nitric acid as nitrate of lime, and also gave a decided re-action of phosphoric acid. These results coincide with previous observations under similar circumstances. The nitric acid, in its well-known downward course, had exchanged its soda for the lime of the soil, and at the same time carried some of the phosphoric acid of the previous dressing into the subsoil, and ultimately into the drainage-water.

The facts disclosed by Professor Goessmann's analysis of the water which percolated from the lysimeter after its soil had been dressed with chemicals, though perhaps previously known to chemical experts, are worthy the careful attention and study of practical men. It should be remembered that twenty-eight of the thirty-eight inches in soil depth was little better than open gravel, that it was hoed and kept clear of vegetation during the season, and that the chemicals applied were largely in excess of ordinary manuring. Yet in no case did the drainage-water contain more than the slightest traces of any thing which had been applied. It is also apparent that the power of soils to take and hold salines is not merely a physical one, but may be most essentially modified and increased by chemical action, and in this case caused the

retention of the potassium oxide, the soda, and the ammonia. At the same time, the application of such large quantities of nitric acid and chlorine as were contained in the nitrate of soda and the chloride of potassium, caused the filtration of lime and phosphoric acid.

Temperature.

The following tables show the monthly averages of the temperature of the soil in the lysimeter, and of the air, day and night; it being taken daily at the warmest time of the day and the coldest time at night, but the time by clock varying as the length of the days increased and decreased.

Month.	Temperature of Air.		Temperature of Soil.	
	Day.	Night.	Day.	Night.
Average for May . .	71.10°	53.10°	62.10°	54.55°
for June . .	79.63°	58.66°	82.63°	64.43°
for July . .	88.32°	62.68°	90.68°	67.39°
for August .	80.48°	56.90°	82.10°	62.52°
for September .	80.60°	49 40°	79.20°	58.80°
for October .	63.61°	40.48°	65.19°	49.62°
for November .	46.83°	26.43°	42.53°	37.29°

The table shows that the average temperature of the air by day, for the season, was 72.940°, and that of the soil, 72.061°. The average temperature of the air at night was 49.664°, and that of the soil, 56.370°. As the night temperature was taken at its supposed lowest point, it was possible that it did not give what might be called the average difference for the entire night between the soil and the air, and that if, instead of taking it just before daylight in the morning, it should be taken the previous evening, a very different result might be obtained. Observations were therefore made every night in the month of June, at ten P.M. The average temperature as found at that time was, for the air, 58.300°, and the soil,

64.430°. It will be noticed that the average difference is almost identical; that of the former showing the soil to be 6.706° warmer than the air, and the latter 6.130°.

Temperature of the General Soil.

As the recorded temperature of the air and soil at night, from the 22d of May, showed the soil in the lysimeter to be warmer than the air, a series of somewhat random investigations was made over the surrounding country, within two miles of the College, to ascertain whether this comparative temperature was in accord with the general fact; and the following are the recorded results. June 11, four A.M. — Garden-soil, 50°; air, 49°. Grassland recently mown, soil 54; air, 49°. Grassland covered with heavy crop, soil 54°; air, 49°. June 12, four A.M. — Garden-soil, 48°; air, 44°. Grassland recently mown, soil, 54°; air, 44°. Grassland covered with heavy crop, soil, 54°; air, 44°. Peat-swamp, wet, but covered with grass, soil, 53°; air, 43°. Peat-swamp, wet, but without grass, soil, 51°; air, 42°. June 16, four A.M. — Garden-soil, 60°; air, 58°. Grassland recently mown, soil, 62°; air, 58°. Grassland covered with heavy crop, soil, 62°; air, 58°. Gravelly knoll tilled, soil, 60°; air, 58°. Gravelly knoll in grass, soil, 64°; air, 58°. June 19, four A.M. — Garden-soil, 57°; air, 50°. Sandy loam soil, ploughed and harrowed the previous day, soil, 52°; air, 50°. Cornfield, light sandy loam, soil 54°; air, 50°. Field covered with heavy clover, land very moist, soil, 59°; air, 50°. Under trees in grassland orchard, soil wet, soil, 59°; air, 50°. Same soil, but not under trees, soil, 58°; air, 50°. Same, but soil dry, soil, 60°; air, 50°. Gravelly knoll in grass, soil, 60°; air, 51°. June 28, four A.M. — Garden-soil, 62°; air, 60°. Grassland north of building where sun's rays do not strike between nine A.M. and five P.M., soil, 64°; air, 60°. Clay-plot, very wet, soil, 63°; air, 60°. At brookside, mud, 62°; air, 59°. July 1, at half-past two A.M. — Wet grassland near Mill River, soil, 71°; air, 66°. Sandy knoll covered with growing grain, soil, 70°; air, 66°. Sandy loam grain-field, soil, 68°; air, 66°. Sandy knoll without grass, soil, 69°; air, 66°. Tobacco-field near Connecticut River, soil, 68°; air, 66°. Grassland on river-bank, soil, 70°; air, 65°. Centre of large forest, soil, 66°; air, 67°. Turf-land outside of woods, soil, 70°; air, 66°

Woodland on hill, soil, 66°; air, 66°. The average night temperature of the soil as found by these investigations was 66.13°, and of the air 60.75°, showing that the general soil of the vicinity had a higher average temperature than that contained in the lysimeter. Of the whole series, but one record was made of air temperature higher than the soil, and that was in the centre of a dense forest, and on a night succeeding a day when the thermometer indicated 102° at half-past two P.M., and the air of the night was remarkably still. These investigations were made at odd times snatched from other duties or from sleep, and were thought not to be so methodical in relation to dates and varieties of soils as the importance of the subject demanded. Another series was therefore instituted, the investigations to be made the 5th, 16th, and 26th of every month, in forest-land, cultivated land dry and wet, grassland dry and wet, and at the surface of the soil, and at a depth of five inches. By dry land, land which had moisture on the surface of its particles is meant, and by wet land, that which had water standing between its particles, and, in most cases, that in which the impression left when the thermometer was withdrawn would fill with the liquid. The following is the record of the monthly averages: —

MONTH.	Dry Cultivated Soil.			Wet Cultivated Soil.			Dry Grassland.			Wet Grassland.			Forest Soil.		
Average for	4 A.M. Air.	Surface Soil.	Soil 5 inches deep.	4 A.M. Air.	Surface Soil.	Soil 5 inches deep.	4 A.M. Air.	Surface Soil.	Soil 5 inches deep.	4 A.M. Air.	Surface Soil.	Soil 5 inches deep.	4 A.M. Air.	Surface Soil.	Soil 5 inches deep.
August	57.33°	61.67°	66.22°	55.80°	62.00°	66.00°	52.12°	63.18°	66.36°	54.29°	64.00°	66.71°	57.50°	62.25°	63.25°
September . . .	46.63°	55.00°	58.13°	35.50°	46.50°	56.50°	44.30°	58.30°	62.21°	42.50°	57.67°	60.67°	50.43°	59.38°	60.50°
October	46.00°	52.60°	54.60°	42.75°	51.75°	54.25°	43.05°	54.74°	55.95°	42.20°	53.20°	55.00°	45.86°	54.57°	55.86°
November . . .	21.43°	33.86°	35.71°	20.00°	35.33°	39.00°	19.94°	36.38°	38.50°	20.50°	37.50°	40.67°	22.89°	40.00°	41.33°

The stations of the foregoing observations were long distances apart, on different kinds of soils, and in different exposure; and it is believed they show with accuracy the night temperature of the soil of the country, for the period they cover, in this latitude. The average night temperature of the air for the entire period was 41.036°; the surface of dry, cultivated soil, 50.282°, and, at five inches deep, 53.665°. Wet cultivated soil averaged at the surface 48.895°, and, at a depth of five inches, 53.937°. Dry land in grass averaged 53.150° at the surface, and 55.755° at a depth of five inches. Wet land in grass averaged 53.092° at the surface, and 55.762° at a depth of five inches. Forest-land averaged 54.050° at the surface, and 55.235° at a depth of five inches. The average temperature of the soil to the depth of five inches, as found by the whole investigation from Aug. 1 to Dec. 1, was 53.381°, or 12.345° warmer than the air at night for the same period. It has ever been taught that wet soils, as compared with dry, are cold, from which assumed fact many important conclusions have been drawn; but, if no mistake in observation has been made, this is an error. The average temperature of all the dry soils examined, and to the depth of five inches, was 53.381°; that of the wet soils to the same depth was 52.921°, or 460° colder. Practically the temperature is the same. The temperature of dry soils by day is higher than that of wet, and the diurnal variation greater; but the equality of temperature at night indicates pretty clearly that temperature is by no means the only factor to be considered in discussing the condition and improvement of wet lands.

The result of the investigations to ascertain the comparative temperature of the soil and air during the night, and in natural conditions, made it more than doubtful if the general belief respecting the comportment of soils to the vapor of water in the air is in agreement with the fact. If I am not mistaken, it is believed and taught, that at night the soil obtains water from the air, and in such considerable quantities as to be of the "utmost agricultural value," and, that in time of scarcity of rain, it invigorates and sustains plants, which, but for this supply, would wither and die. This, we are taught, is the result of the operation of three causes, each of which is worthy of examination and careful analysis. The

first cause is the "hygroscopic property of soils." Water, in both the liquid and vapor forms, seeks an equilibrium. When the substances containing unequal quantities of water are brought in contact, the element passes from the wet to the dry, or from the moist to the less moist substance. It is assumed that the soil is the dry, and the air the moist object, and during the night there is a movement of water from the latter to the former. This is accepted as a proved fact by the experiments of Schubler, Davy, and others. But all those experiments were tried under such perfectly unnatural and distorted conditions, that it is more than doubtful if they illustrate the natural fact in the case. In those investigations the soils experimented with were first carefully and thoroughly dried by heating to 212° F., and were then confined over water in saturated air. They absorbed the vapor of the water, and increased their weight. But that is not singular. A plate of burnished steel or flint-glass would have done the same thing, — would have absorbed moisture after heating to 212°, even in the atmosphere of a warm room; and the experiments do not show any peculiar property of soils in this respect, nor prove, that, in natural position in the field and in free air, they would absorb vapor. That soils are hygroscopic there is no doubt; but such investigations do not reach the case. By an examination of the soil of a cultivated field in time of drought, or in average summer condition, the following facts will be found: first, a thin layer of soil on the surface fully exposed to the air, and which, if not in absolute hygroscopic equilibrium with it, is simply air-dry: it must contain more rather than less water than the air in contact with it, and it lies on, and is intimately connected with, a lower layer of soil, which contains not only hygroscopic water, but moving capillary water, which is constantly passing upward to it, and through it into the air; and both the lower and upper layers have a higher temperature at night than the air. These being the facts respecting the condition of the soil and air, it is hardly possible that the film of water found on the surface of the upper layer of soil on a summer morning could have been received from the air; but it would be very natural and reasonable that it should be moisture which arose from the lower layer, and was condensed on the surface by the colder air of the night.

The second influence which causes absorption of water by the soil from the vapor of the air is stated as follows: During the day the soil absorbs the heat created by the sun's rays, and becomes very warm. At night this heat is radiated, and the soil cools rapidly, becoming colder than the air at or near its surface. It thus cools and condenses the vapor it contains, which is deposited upon and absorbed by the soil. To this theory there are some objections, and many natural facts it is difficult to explain by it. For example: a cock of hay standing on a dry gravel-knoll during the night will always be found in the morning quite moist entirely through at the bottom. The mower drops his scythe-stone on the ground just at nightfall: in the morning he finds it dry on the top, and covered with water below. A board is thrown upon the ground at night: in the morning it is dry on the top; but the bottom is wet. Now, it is a fact, that all soils are warmed, and evaporate watery vapor, during the day; and it may be said that in these and similar cases, as the soil is covered at night, its heat is not radiated, and evaporation continues, which would be checked but for the covering, and this causes the local moisture beneath. This is undoubtedly true to a certain extent. But allow the hay, the board, or the stone, to lie on the ground during the following day, or many days, so that the soil cannot be warmed by the heat of the day, and it will become comparatively cold; yet every night moisture will accumulate beneath. But, if no mistake has been made in relation to the comparative temperature of the soil and air at night, this theory cannot be true. If the average night temperature of our general soils is 12.345° warmer than that of the air, there can be no condensation of watery vapor caused by the soil, there is no absorption by it of water from the air; but the natural phenomenon of evaporation from the soil is continued through the night, though less rapidly than in the daytime.

The last natural influence given as conveying water from vapor to the soil is called "dew-fall," and is almost identical in principle and result with that just considered as condensation and absorption. The principle is fully and clearly illustrated by the phenomenon of the "ice-pitcher." The vessel filled with iced water during a warm day, when the air has a high per cent of humidity, soon has its outside covered with

a perceptible film of moisture, which rapidly increases; and soon liquid water is trickling down its side. This is water condensed, and taken from the air; and the belief is, that at night the soil is in the same relation to the air as the pitcher during the day, and in like manner receives water. This whole matter is one vastly too important to be left undetermined except by speculation; and an extensive series of investigations was instituted to ascertain the precise facts. And, first, does the soil stand in the same relation to the air as the "ice-pitcher" in the illustration given? If so, then the pitcher filled with soil directly from the field would be soon covered with moisture.

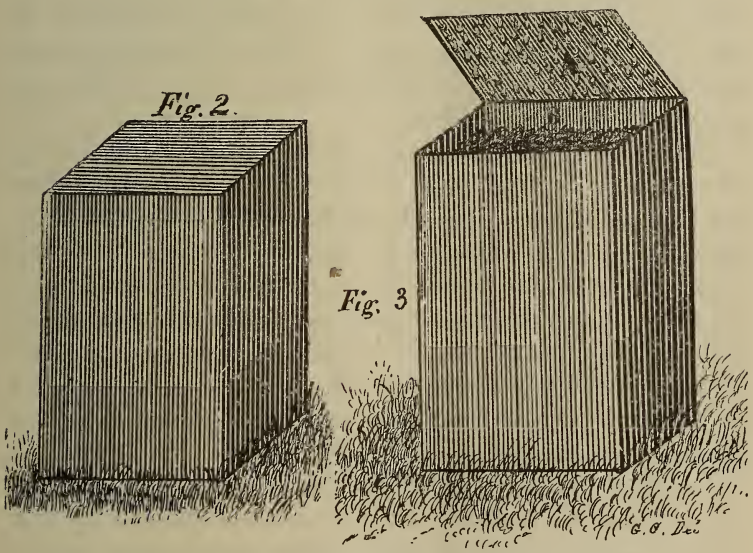


Fig. 2. The box containing soil, with the lid on, but no dew on the outside.
Fig. 3, A. The box with the lid raised, showing the water on the under side.
Fig. 3, B. Soil in the box.

Experiment 1. — A can of thin tin was prepared, which was three inches square, five inches deep, and without top or bottom. At eight o'clock of the evening of July 20, it was filled with soil from a cultivated field, in the same manner as the soil is taken into a lysimeter. It was placed on a grass-plot, and there remained until the morning of the 21st, and, though the surrounding grass was loaded with dew, there was not the slightest trace of it on the box. At four A.M. of

the 21st the temperature of the soil in the box was 66°; that of the air was 60°. The experiment was repeated many times, with identical results. The soil does not bear the same relation to the air as the "ice-pitcher." On the night of July 25 a loose cover was placed on the top of the box: on the succeeding morning the top of this cover was dry; but the under side, next to the soil, was thickly studded with drops of water. Plate II., Figs. 2 and 3, represent this device.

The principle illustrated by the "ice-pitcher" is a natural one; but it does not apply to the soil: in this case the soil becomes the warm, moist substance, performing the office of the air, and the air the cold substance, condensing its evaporating water. If the soil of the field gathers water from the air at night, then a given portion of it in natural position will be heavier in the morning than at night; if it evaporates water, it will be lighter.

Experiment 2. — Two boxes were prepared with capacity of a cubic foot. They were filled with soil in the same manner that soil is taken into a lysimeter, and without disturbing its particles, or disarranging its strata. One was filled with absorbent, retentive loam, the other with peat; and these soils were taken, because it was supposed that evaporation from them would be less rapid than from gravel or sand. Tight bottoms were nailed upon them, and they were placed in a trench in the open field, level with the surrounding ground, and exposed to all the vicissitudes of the weather. The experiment commenced the 1st of June, and was continued through the month, except when interrupted by rain or fog, the boxes being weighed night and morning. It will be noticed that the increase and decrease of the weight was not uniform, which was due to varying amounts of rainfall; but the results were as follbws: —

DATE.	LOAM.						PEAT.					
June.	EVENING WEIGHT.		MORNING WEIGHT.		GAIN.	LOSS.	EVENING WEIGHT.		MORNING WEIGHT.		GAIN.	LOSS.
	lbs.	oz.	lbs.	oz.	oz.	oz.	lbs.	oz.	lbs.	oz.	oz.	oz.
1 .	110	4	110	1	0	3	112	0	111	8	0	4
2 .	109	2	109	2	0	0	110	2	110	0	0	2
3 .	108	9	108	8	0	1	108	12	108	12	0	0
4 .	108	0	108	0	0	0	107	6	107	7	1	0
5 .	107	1	106	15	0	2	105	1	105	2	1	0
6 .	106	6	106	5	0	1	103	13	103	10	0	3
7 .	105	14	105	11	0	3	102	5	102	1	0	4
9 .	115	8	115	5	0	3	109	0	108	13	0	3
14 .	115	12	115	9	0	3	109	4	109	0	0	4
15 .	114	9	114	8	0	1	107	9	107	8	0	1
17 .	113	13	113	13	0	0	106	9	106	7	0	2
19 .	112	4	112	2	0	2	104	4	104	2	0	2
20 .	109	4	109	3	0	1	103	14	103	12	0	2
21 .	110	6	110	6	0	0	101	13	101	12	0	1
23 .	116	12	116	12	0	0	107	7	107	6	0	1
28 .	115	15	115	13	0	2	106	14	106	14	0	0
29 .	114	6	114	4	0	2	105	2	105	1	0	1

This experiment, though not conclusive, indicates that the soil at night evaporates water, and that it is possible that the little moisture we find on the surface of a field in the morning may have been received from deeper soil rather than from the air. But the experiment was crude, the weights taken large, and the danger of mistake in exact fine weighing imminent: therefore the fact was sought by a different method.

Experiment 3. — A tin cup or can was prepared, seven inches in diameter and eight inches high, and holding 308.67 cubic inches of air. The sides were made double, but with the tin plates an inch and a half apart to contain water to reduce the temperature within the can to the same degree as the air outside: it was without bottom, but had a top through which was an orifice made tight by a cork, but in which was an aperture to insert a thermometer. It was well soldered; so that when it was put down upon, and its lower edge cut into, the soil, it was practically air-tight. For the purpose of absorbing moisture a piece of fine sponge was taken of twenty grams' weight. The sponge was placed under the can on a pine pin two inches above the ground or board, on which the cup was alternately placed, and was weighed night and morning. It was assumed, that, if the water

absorbed by the sponge came from the air, there would be a marked uniformity in the weight of the sponge, whether the can stood on the board or the ground; but, if it came

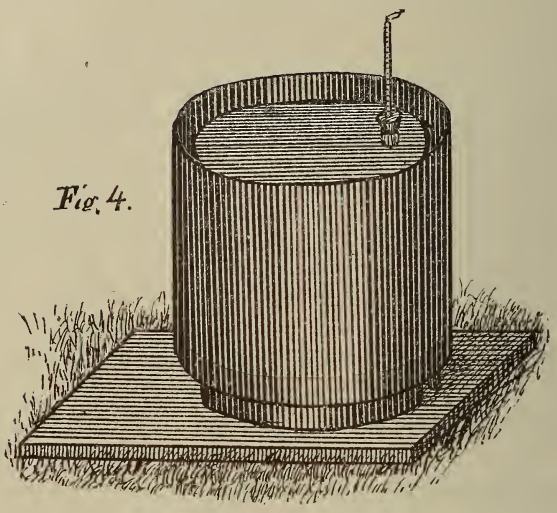


Fig. 4. The can as used on a board.

from the soil, its weight would be greatest when the board was removed. When the can stood on the board, the outside

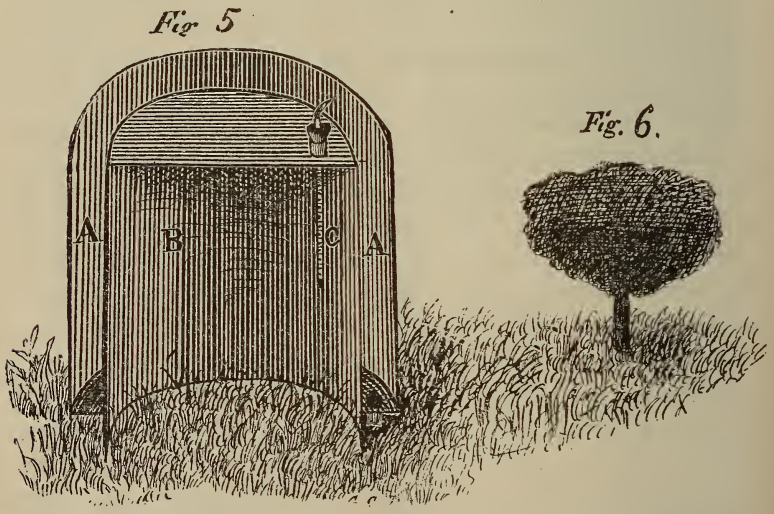


Fig. 5. A vertical section of the cup. A, space for water; B, inner space; C, thermometer.
Fig. 6. The sponge on the pin as covered by the can.

air was excluded by banking around the bottom with dry soil. Plate III., Figs. 4, 5, and 6, represent this device.

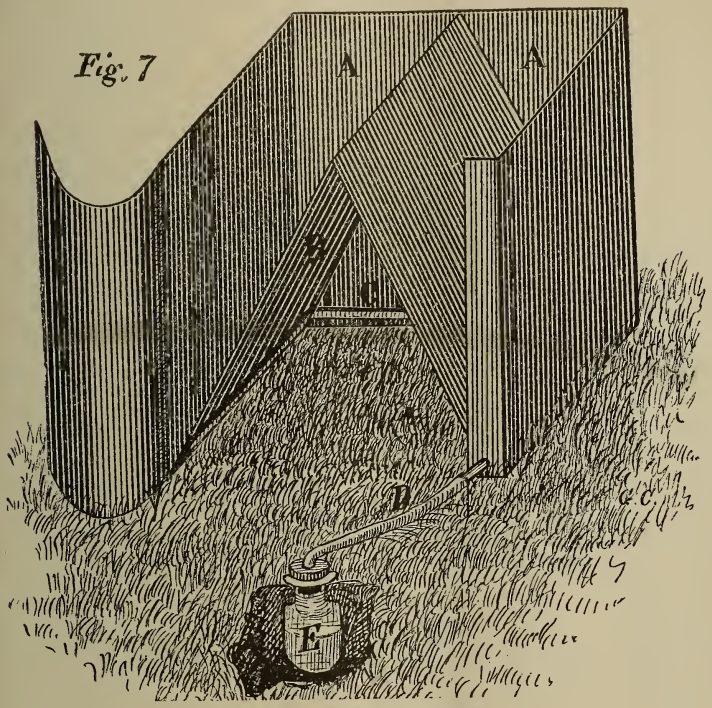
The following table exhibits the result of the trial: —

Date.	Per cent of Humidity in Air.	Inside Temperature.	Outside Temperature.	Cup on Board. Moisture on Sponge.	Cup on Ground. Moisture on Sponge.	Temperature of Soil.	Remarks.
[6] June 7	67	54°	52°	–	3.00 grams	68°	
" 9	86	51°	49°	–	2.35 "	56°	
" 10	92	51°	49°	–	3.10 "	52°	Rain previous day, and soil wet.
" 12	88	50°	48°	.030 grams,	–	53°	
" 13	88	58°	53°	.431 "	–	60°	
" 14	72	52°	50°	.620 "	–	68°	
" 15	88	58°	58°	.550 "	–	65°	
" 16	62	58°	59°	–	1.76 "	65°	
" 17	74	60°	58°	–	1.43 "	64°	
" 19	70	52°	50°	.245 "	–	64°	
" 20	88	59°	58°	–	2.76 "	70°	
" 21	70	55°	54°	.250 "	–	67°	
" 23	83	58°	56°	–	1.94 "	66°	
" 24	87	59°	59°	–	4.50 "	66°	
" 25	87	54°	57°	.740 "	–	62°	
" 28	95	62°	60°	–	2.88 "	69°	Ground not hoed after rain.
" 29	96	65°	64°	–	4.16 "	77°	Ground just hoed, and very moist.

Rapidity of evaporation from any object is supposed to be according to its temperature and the amount of water it contains, modified by the motion of the air, its temperature, and its per cent of humidity. But the table does not show by the amount of water collected over the ground or board, any special uniformity in this respect. It is noticeable that when the air under the can was comparatively dry, as on the nights of the 16th, 17th, 19th, and 21st, the least water was collected; but no attempt was made to ascertain, if, during that time, its humidity was increased by the soil evaporation, or decreased by sponge absorption on the nights of the 10th, 20th, 28th, and 29th, when it had a high per cent of moisture, and sponge contained the most water. It is quite possible, however, that, when the humidity of the air was near the point of saturation, the sponge received all the water evaporated by the soil, making its quantity large, and, on the other hand, when the air was dry, that received and held a portion of the evaporation, making the sponge collection small. As a rule, the amount of moisture taken by the sponge was largest immediately after rain, when the soil was wet, and at a high temperature. The result, as a whole, corroborates the conclusions drawn from the second experiment. The amount of water collected, though small, must have been received principally from soil evaporation; but it does not determine what the maximum evaporation would be if the soil had not been covered by the can; for, as the contained air approached saturation, the sponge would not fully relieve it, and there must be a diminution in the soil evaporation. Therefore the more completely to eliminate the whole truth, the investigations were continued in the following manner.

Experiment 4. — A double vessel of thin tin was prepared, which within would cover one square foot of soil, and contain half a cubic foot of air, and of the same holding-capacity in the outside receptacle. On the inside, one inch above the bottom edge, a gutter was soldered on the four sides, slightly inclining to one point, and connected with a tube which passed through the side of the vessel; a tight-fitting rubber-hose was drawn over this, and its outer end inserted in a phial. When in use, the lower edge of the vessel was cut into the soil to the depth of one inch, or as deep as the gutter would allow, to exclude the external air, and the outside re-

ceptacle was filled with ice and water to act as a condenser of the water-vapor within. The can is represented by Plate IV.



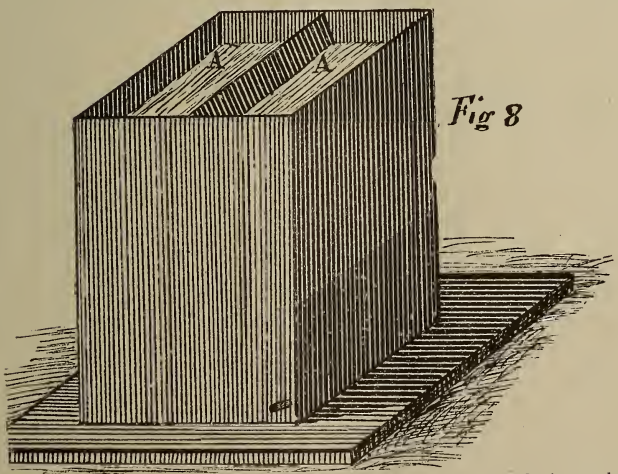


Fig. 7. A vertical section of the can, with side turned away to show the internal arrangement. A, A, water-space; B, air-space; C, gutter to catch water; D, rubber tube to conduct water from gutter to jar; E, water-jar. Fig. 8. Can as used on a board. A, A, ice-cold water.

The results of its use on cultivated and sod-land, and on a board, were as follows: —

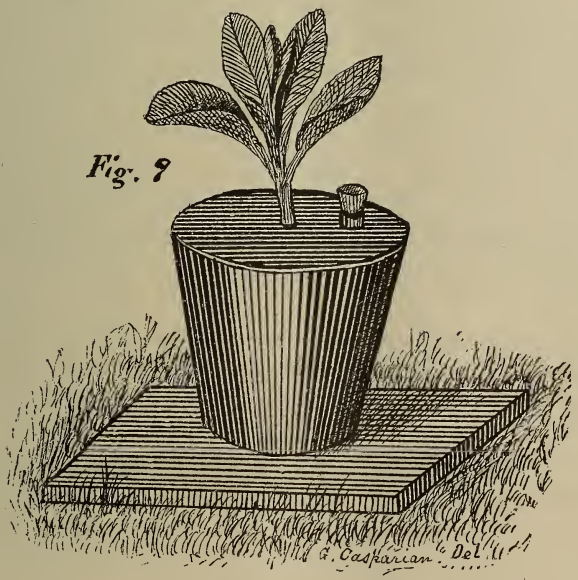
Date.	Per cent of Humidity of Air enclosed.	Actual Water in Air enclosed.	Actual Water obtained.	Gain over that contained in the Air enclosed.	Amount of Water obtained per Acre.	Temperature of the Outside Air.	Temperature of the Soil.	Remarks.
Night of		grams.	grams.	grams.	barrels.			
July 8 . .	82	0.1555	2.550	2.3945	8.950	70°	75°	A leak at the tube.
" 9 . .	96	0.3045	19.220	18.9155	70.941	76°	79°	Vessel on garden soil recently hoed.
" 10 . .	95	0.2786	33.060	32.7814	122.216	76°	79°	Soil wet by heavy rain previous day.
" 13 . .	92	0.2267	.445	0.2183	0.818	70°	74°	Vessel on a board.
" 15 . .	82	0.1555	13.050	12.8945	48.364	68°	74°	Vessel on dry sandy land.
" 16 . .	86	0.1684	17.430	17.2616	64.745	65°	72°	Vessel on grassland, and grass under it, loaded with dew, but little on grass outside.

The water collected in this experiment was the evaporation from a square foot of surface, and, though so small as to be hardly appreciable for that area, yet in nature it is a vast movement, as can be seen by noticing the collection of the night of July 10, when it was at the rate of more than a hundred and twenty-two barrels per acre. This may or may not be the maximum of soil evaporation at night; but it conclusively proves that the law of evaporation is not suspended or contravened, but is in active operation, at night, modified, of course, in degree by those influences which affect it during the day. The drift of the four separate investigations is clearly in one direction, and teaches, that in the open field, with soil and air in natural condition, — the general soil, the upper stratum or film of air-dry soil, — lifeless substances lying on the ground or near it do not absorb water from the comparatively cold, dry air, but obtain it directly from the water which is being evaporated by the warmer and more moist soil. On this principle, and this alone, can the phenomena to which allusion has been made be understood or explained, or that more striking natural appearance commonly known as "ground fog." This is seen during the night, when there is no perceptible motion to the air, as a compact sheet of mist of one or two feet in thickness, and resembling a covering of snow, and always over water or very wet land. The surface-soil beneath the fog is many degrees warmer than the air, and contains hundreds of times more water in an equal space. Its abundance and warmth cause rapid evaporation, which is immediately condensed and made visible by the colder air. The principle which these observations appear to establish as governing the natural relations which exist between the soil and water in both the liquid and vapor forms, and its movement thence to the air, may have a more extended influence and application than has now been given it, and exhibit the cause and process of "dew-fall" in the case of the living plant; which phase of the subject should here receive our careful examination.

Allusion has already been made to the principle of "dew-fall" as illustrated by the "ice-pitcher;" and dew is described as "moisture from the atmosphere condensed by cool bodies on their surfaces at night. With the principle and the fact as stated, the belief appears to be and is in harmony, if no

mistake is made in the application. It is, however, pertinent to inquire if this universally-accepted and time-honored theory of "*dew-fall*" is consistent with many well-established laws of plant-life and many well-known natural phenomena. And, first, the plant is endowed with a most wonderful and elaborate system of roots, extending deep, far, and wide in the soil, which has a temperature at night many degrees warmer than the air, and saturated with water of its own temperature. The most important function of this root-system is to gather soil-water, and force it upward, through every part of the structure of the plant, to the leaves. Their power is so great, that when the plant is in rapid growth, and there is a full water-supply in the soil, it is subjected to great pressure. The root-force of plants has been frequently investigated, but never more completely, or with a clearer or more decided record, than by the experiments at the Agricultural College, under the direction of President Clark, in the years 1874 and 1875. It is recorded in those experiments that the pressure exerted by a birch-root severed from its connection with the tree was equal to a column of water 85 feet in height; and that of a squash-plant eight weeks old, soft, open in its texture, and very tender, exerted a force equal to a column of water 45.5 feet high. Such plants as corn, tobacco, and the dahlia, exhibited a similar power. The leaves, acting in conjunction with the roots, pass nearly all the water thus forced into their tissues, through their stomata, into the air. A rapidly-growing calla in the College conservatory has been noticed to exude water from its leaf-pores in such quantity as to stand upon the surface or fall to the ground in large drops. An Indian-corn plant, during its season of growth, has been found to evaporate thirty-six times its own weight of water. It has been stated, after careful investigation, that the leaves on an average acre of forest exhale many thousand tons of water during their summer growth, and a sunflower-plant has evaporated three pounds in twenty-four hours. There is no natural reason why this evaporation should not be constant during growth, modified only in quantity by the supply of water in the soil, its temperature as affecting the activity of the roots, the rapidity of the motion of the air, and its content of water. Second, young, succulent, rapidly-growing plants standing in the field by the side of those nearly

ripe and comparatively dry always exhibit much the most dew. Third, other things being equal, those leaves and plants nearest to the ground "collect" the most dew. Fourth, other things being equal, plants growing on soils fully supplied with water show more dew than those on dry land. The Colorado wheat-grower, producing his crop by irrigation, determines when his lands are dry, and need watering, not by examining the *soil*, but by viewing the growing *crop* early in the morning. If this is well covered with water, he knows the soil is moist; if it has little or none upon it, it is the reverse, and the irrigating-sluices are at once opened. Fifth, some plants, at certain stages of their existence, have



dew upon them, if the direct rays of the sun do not strike them, although it is several hours above the horizon, and the temperature several degrees above the "dew-point." These phenomena may not prove that plants do not receive their dew from the air; but they give occasion for serious doubts, and indicate the possibility that it may come from the plant itself, or be a deposit of moisture rising from the soil as in the case of the "ground fog." A consideration of the mutual relations of root-action and leaf-evaporation leads to the conviction that it is hardly possible that the force or the result is one of diurnal periods, as in the case of the opening and closing of certain flowers, but rather that the cause is active

day and night, unintermitted during the period of growth. But the positive fact could be proved only by investigation, and was, therefore, attempted in the following manner: Do plants evaporate water at night? Two petunias and a cabbage-plant were selected, of convenient size for the experiment, and in thrifty, growing condition. A tin pot was prepared for each, in which they were potted and soldered in. Tubes were inserted in the top and bottom to admit water, and for drainage. The orifice around the stems was closed perfectly with grafting-wax, and, when on trial, the apertures for water and drainage were plugged with rubber-lined corks, so that it was impossible for any thing to escape from the pots but through the stems and leaves of the plants. In this condition the plants, with their pots, were weighed night and morning. The corks were removed during the day, and the plants watered as their health required. Fig. 9 represents one of these plants as potted for use. Plants show no dew when kept at night in a sitting-room, a conservatory, or under a roof; and to know if, during that time, evaporation was taking place, one of the petunia-plants was kept under cover, and weighed evening and morning, with the following result: —

Date.	Evening Weight.	Morning Weight.	Loss.	Gain.	Remarks.
	grams.	grams.	grams.	grams.	
June 10 . .	240.040	238.260	1.78	0	Temp. of room, 53°. Humidity of air, 88.
" 11 . .	231.050	229.850	1.20	0	Temp. of room, 55°. Humidity of air, 70.
" 20 . .	224.130	222.910	1.22	0	
" 21 . .	233.065	231.855	1.21	0	
" 23 . .	229.595	228.335	1.26	0	
" 24 . .	233.635	232.445	1.19	0	
" 25 . .	230.575	229.145	1.43	0	
" 26 . .	220.605	219.395	1.21	0	
" 28 . .	228.355	226.975	1.38	0	
" 29 . .	214.785	213.325	1.46	0	
" 30 . .	233.825	232.295	1.53	0	

Though the result shows no regularity of loss in proportion to the whole weight, yet the unvarying decrease proves conclusively that one plant evaporated water at night, and indicates clearly that that may be the law of all, whether situated in the open air or in a room. But, to prove or disprove this supposition, one of the potted petunias and the cabbage-plant were nightly placed in the open air in the garden, with the pots thoroughly wrapped in cloth to prevent their collecting water from the soil, and with results as follows: —

Petunia-Plant.

Date.	Evening Weight.	Morning Weight.	Loss.	Gain.	Temperature of the Air.	Per cent of Humidity.	Water on the Plant.
	grams.	grams.	grams.	grams.			grams.
June 13	221.700	218.370	3.33	0 00	52°	88	–
" 14	246.800	246.550	0.25	0.00	60°	72	–
" 15	252.900	251.460	0.44	0.00	61°	88	–
" 17	242.880	242.160	0.76	0.00	62°	74	–
" 20	148.060	148.240	0.00	0.14	64°	88	–
" 21	169.125	169.165	0.00	0.35	61°	70	–
" 25	167.905	167.605	0.30	0.00	56°	66	0.52
" 26	165.305	165.105	0.20	0.00	57°	87	0.93
" 29	158.955	158.925	0.43	0.00	72°	96	0.38
July 6	158.395	158.155	0.24	0.00	83°	65	0.46

Cabbage-Plant.

Date.	Evening Weight.	Morning Weight.	Loss.	Gain.	Temperature of the Air.	Per cent of Humidity.	Water on the Plant.
	grams.	grams.	grams.	grams.			grams.
June 26	234.685	232.725	1.96	0.00	57°	87	1.80
" 27	259.005	254.775	4.23	0.00	63°	91	2.77
" 28	250.720	250.805	0.00	0.85	64°	93	4.87
" 29	238.255	237.705	0.55	0.00	72°	96	4.15

Cabbage-plant placed under tin can on a board, and the temperature reduced.

Date.	Evening Weight.	Morning Weight.	Loss.	Gain.	Temperature of the Air.	Per cent of Humidity.	Water on the Plant.
	grams.	grams.	grams.	grams.			grams.
June 30	253.145	248.925	4.22	0.00	73°	–	1.32
July 5	203.745	198 955	4.79	0.00	66°	–	0.90
" 6	173.875	173.405	0.47	0.00	51°	–	0.47

No attempt was made to determine the amount of water on the plants as dew until the 25th, when, after the morning weighing, the leaves were wiped with a soft sponge as dry as possible, and the plant re-weighed. It will be noticed, that, on nights when the plants lost weight materially, they at the same time had dew upon them. This is explained by the fact that frequently the plants stood in the garden several hours before they gathered moisture: at other times it commenced gathering very soon after they were carried out. It may be, that, in the former case, the loss was occasioned by evaporation which was not condensed. It was assumed that if the plants in the morning, with the dew upon them, weighed more than at night, it would be proof that the dew came from the general air, or moisture arising immediately from the ground; if they weighed the same, or less, it must have exhaled from and accumulated on the leaves. The result is not an absolute demonstration; but it furnishes the missing link in the chain of evidence which will enable us to deduce conclusions having all the force of principle; and, that the evidence may be distinctly seen in its proper relations, we recapitulate. The declaration is made, "that dew on plants is water of vapor of the air, which is deposited on cold objects at night, it being condensed thereby." Proof: The exhibit of the "ice-pitcher." Answer, 1st: The pitcher is at least twelve degrees colder than the surrounding air, and on the outside hygroscopically much dryer; and plants at night are, on the average, at least as warm as the air, and could not condense it. Answer, 2d: The natural office of the leaves under force and pressure of the roots is to exhale water into the air, and they do it at night, nearly regardless

of temperature. Answer, 3d: Some plants exhibit dew in the daytime, if removed from the evaporating influence of the direct rays of the sun, and when the temperature of the air which surrounds them is many degrees warmer than what is technically termed the "dew-point." Answer, 4th: Plants abundantly supplied with, and containing, the largest per cent of water, and whose roots and leaves are the most active, exhibit the most dew. Answer, 5th: In time of severe drought, plants have little dew, though there is a high per cent of moisture in the air, and the nights are cold. Is it probable, then, that living, growing plants are under the control of the law exhibited by the "ice-pitcher," or has a mistake been made in the application of the principle?

But, again: the declaration is made, that dew on plants is caused by condensation, by the air, of warm vapor as it rises from the soil, and which therefore collects on plant-leaves. Proofs. 1st: The vapor of the soil is much warmer at night than the air, and would be condensed by it. 2d: Vapor from the soil is soon diffused and equalized in the whole atmosphere, but is in largest proportion when evaporation is taking place near the surface of the soil; and, other things being equal, leaves and plants near the earth have the most dew. 3d: Dew under boards, hay-cocks, and like objects on the ground, could receive it from no other source. Answers. 1st: Admitting the facts, can they annul or make inoperative the law of evaporation from the surface of leaves at night, and its condensation there? 2d: Living organisms in the action of their functions are superior to, supersede, and in a measure control, the laws of dead substance; and the subject-matter of dew relates more specifically to the living herbage of the fields. 3d: Water on the leaves of a plant on a board under a can could not have been received from the ground. The declaration is here made, that dew is the condensed exhalation of the plant. Proofs. 1st: Plants evaporate water at night. 2d: The air is colder than the plant and its exhaled vapor, and would condense it at the surface. 3d: The great preponderance of testimony is, that, other things being equal, plants with the dew on them weigh less in the morning than on the previous evening, which could not be possible if it was received from any foreign source. 4th: A plant confined at night or during the day

from the general air and the ground will, if the temperature is reduced, have more dew upon it after eight hours' seclusion than all the water in the air with which it is confined. Though of the greatest importance to the cultivator of the soil, the natural phenomena we have thus investigated are so extremely subtle and delicate in their nature as to make absolute demonstration a matter of the greatest difficulty. But the facts obtained harmonize quite perfectly with the known natural laws of the absorption, retention, and radiation of heat by different kinds of matter, and the movement and changes of form of liquid water in the soil and plant. They give a rational and consistent explanation of many facts and phenomena which have been enveloped in more or less of mystery, and may direct to better or more intelligent methods in the treatment of soils and crops.

If the facts are as they appear, the soil receives no water from the air in the form of vapor, but liquid water, as rain or fine falling mist. Its evaporation is rapid; and proper means should be employed, when the supply is deficient, to conserve it for the time of sorest need. Our climate is one of extremes, and is not so favorable for the development of plant-food out of crude material as that of many countries. The mean of meteorological influences during the season gives us abundant crops; but, if the season is characterized by extremes, the crops are materially diminished, if not destroyed. Extremes of water-supply and temperature, as "cold and wet," "hot and dry," are the farmer's most formidable difficulties, and how the soil should be treated in such emergencies to avoid or mitigate their blighting effects, is a matter of much moment. In time of drought, with the soil at a high temperature, and the little water it contains rapidly moving to the surface and passing away, with crops withering and dying, can the farmer do any thing to save it for the benefit of his plants? Will tillage save it, or hasten its dissipation? Should the farmer cultivate and hoe in such emergency, or allow the soil to remain untouched? Being aware that in this matter opinions and practices differ widely, and that both extremes could not be correct, the subject has been investigated by the following method.

Six boxes were prepared of a cubic foot capacity, and were filled with soil, immediately after a rainfall of .78 of an inch,

without disturbing the position of its particles or strata. The soils were taken from fields in cultivation with corn, and manured on the surface with yard-manure. Two were filled with light, sandy loam; two with heavy, retentive loam; and two with heavy, clayey loam or clay. After the soils had been taken into the boxes, the latter were fitted with tight bottoms, weighed, and placed in a trench, with their surfaces level with the surface of the ground. The soil in one box of each variety was well hoed every morning, and turned over to the depth of four inches, pulverizing and bringing up the moist soil to the surface. The experiment extended through seven days, — from June 26 to July 4, — and was closed in consequence of approaching rain. During the time the weather was very warm, and the sky clear of clouds both day and night, the average day temperature of the soil was 98.14°, and of the night, 70.85°. The average day temperature of the soil was 95°, its night temperature 67°, and the average humidity of the air 70. The afternoon of July 4, the boxes were all re-weighed, and the shrinkage of each variety of soil, and of that tilled and untilled, recorded. The results were as follows: The box of clay soil which was tilled lost 5 pounds, 5 ounces, or at the rate of 904 barrels per acre; the untilled clay lost 6 pounds, 14 ounces, or at the rate of 1,170 barrels per acre. The untilled clay lost 256 barrels the most per acre. The box of light sand which was tilled lost 3 pounds, 3 ounces, or 542 barrels, 12 gallons, per acre; the untilled lost 7 pounds, 8 ounces, or at the rate of 1,276 barrels per acre. The untilled lost 734 barrels the most per acre. The box of heavy loam which was tilled lost 6 pounds, 13 ounces, or at the rate of 1,106 barrels per acre; the untilled lost 7 pounds, 13 ounces, or at the rate of 1,329 barrels per acre. The untilled lost 223 barrels more than that tilled. The average diurnal loss of water by evaporation per acre was, from the tilled clay, 129 barrels, from the untilled, 167 barrels; from the tilled sand, 77 barrels, from the untilled, 182 barrels; from the tilled heavy loam, 158 barrels, and from the untilled, 189 barrels. In other words, a farmer who should as thoroughly cultivate an acre of land in similar weather, and during the same time, would if it was heavy loam save 223 barrels, if it was clay 256 barrels, and if it was sand 734 barrels of water, which would be lost

if it remained uncultivated. The lesson is, cultivate the land to save crops from the dire effects of drought. The quantity of water evaporated is surprising; but it does not tell the quantity which would have been carried off if the soil had been in perfectly natural position. The bottom of the box prevented the ascension of water from the deep subsoil to take the place of that evaporated, which decreased the evaporation, and made the soil dryer than that which surrounded it.

At first thought the result of this experiment is a perfect enigma. We turn over and shake up our hay and other objects that they may dry the faster, and produce that result. But in this case the disturbance of the soil — the turning of it over, and bringing the moist soil to the surface, and exposure to the sun's rays and a temperature of nearly one hundred degrees — has retarded drying; yet it is what might have been anticipated, and in accordance with physical laws. The place of the water carried from the surface by evaporation is continually supplied from the deeper soil by capillary attraction. The water moves upward in fine tubes formed by the particles of soil: if the soil is compact, as when beaten down by rain, the tubes are perfect, and the water moves upward to the surface rapidly; but if the tubes are broken up, the soil particles being separated by cultivation, the subsoil water must rise slowly, although the immediate surface is very dry. Heat also has its influence. Solid bodies transmit it more rapidly, and hold it longer, than those which are light and porous. In this case, the boxes with perfect capillary tubes and the most heat (the untilled) must evaporate the fastest. The average temperature of the untilled soil at a depth of six inches was three degrees warmer than that of the tilled. This investigation was repeated three times between recurring rains, a change being made in each case of the soil tilled, and with identical results in the proportion evaporated by the tilled and untilled; but the total quantity lost varied with the change of temperature.

But drought is not the only water difficulty with which the farmer has to contend. Superabundance of the liquid is as injurious as its scarcity, and one of these extremes is liable to succeed the other. Retentive soils, drained or undrained, may by great and constant rains become so completely water-

clogged as to retard the growth of crops by suffocating or drowning the roots. In such an emergency can any thing be done to give immediate relief? Will tillage do it? We have just seen that this preserves the water; but then we were at the other extreme, or far removed from the point of saturation; and it may be possible that a saturated soil could be greatly relieved, to a certain point, by breaking its rain-formed crust, and roughening or increasing its surface space for the action of the sun's rays. An investigation was therefore made in this direction. The boxes which have been described were taken from the trench, and drenched with water beyond the point of saturation, and allowed to stand in the air until percolation ceased: they were then weighed, the soil in one of each variety turned over, and loosened to the depth of four inches, and the boxes replaced. The trial continued six days, during which time they were weighed each morning, but not tilled. The result was, that the first day the sand tilled lost 1 pound, 3 ounces; the untilled, 10 ounces. The heavy loam tilled lost 1 pound, 14 ounces; the untilled lost nothing. The tilled clay lost 1 pound, 3 ounces; the untilled, 4 ounces. From the first day there was a proportional increase of the loss from the untilled, which, before the close of the trial by rain, materially exceeded that of the tilled in the clay. The entire loss in each was: Tilled sand, 5 pounds, 13 ounces; untilled sand, 4 pounds. Heavy loam, tilled, 6 pounds, 15 ounces; untilled, 4 pounds, 11 ounces. Clay, tilled, 4 pounds, 4 ounces; untilled, 5 pounds, 15 ounces. It is clear, then, that, in open field-culture, such cultivation gives relief from both these extremes; but it is obvious, that, in the latter case, tillage should not commence until the soil so relieved of its surplus water, that it will not be solidified is by the incident pressure.

For the purposes of this report these investigations were assumed to be completed on the 30th of November; but they will be continued regularly to the end of the year, so far as waterfall and percolation are concerned; and at intervals the temperature of the soil will be examined, in forest and field, beneath the frost-crust if any exists. Their peculiar nature has demanded uninterrupted care, attention, and labor, not only by day, but by night, not only near the homestead, but abroad in the open field and forest, which could not be dele-

gated to assistants. They have consumed a great amount of time difficult to spare from other duties; but if any facts have been found which are new to science, or any method discovered to make old facts more practically useful in the treatment of soils and plants, the compensation will be ample. With this series, these and kindred investigations should be considered not as completed, but only commenced, and should be persistently continued year after year; and it is earnestly to be hoped, that, in the interest of an improved and advanced agriculture, the means may be provided to carry forward and make the work of the station permanent.

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OF

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1878.

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WILLIAM S. CLARK, Ph.D., LL.D.,
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GEORGE MONTAGUE,
Instructor in Book-keeping.

SAMUEL T. MAYNARD, B.S.,
Gardener, and Assistant Professor of Horticulture.

ANDRE A. SOUTHWICK, B.S., Farm Superintendent.

Graduates of 1878.[1]

Baker, David Erastus	Franklin.
Boutwell, Willie Levi (Boston Univ.) .	Leverett.
Brigham, Arthur Amber . . .	Marlborough.
Choate, Edward Carlisle (Boston Univ.)	Cambridge.
Clark, Xenos Young (Boston Univ.) .	San Francisco, Cal.
Coburn, Charles Francis (Boston Univ.)	Lowell.
Foote, Sandford Dwight (Boston Univ.).	Springfield.
Hall, Josiah Newhall (Boston Univ.) .	Revere.
Howe, Charles Sumner (Boston Univ.) .	Boston.
Hubbard, Henry Francis (Boston Univ.)	New Rochelle, N.Y.
Hunt, John Franklin	Amherst.
Koch, Henry Gustave Heath (Boston University)	New-York City.
Lovell, Charles Otto (Boston Univ.) .	Amherst.
Lyman, Charles Elihu (Boston Univ.) .	Middlefield, Conn.
Myrick, Lockwood	Concord.
Osgood, Frederick Huntington (Boston University)	Cambridge.
Spofford, Amos Little (Boston Univ.) .	Georgetown.
Stockbridge, Horace Edward (Boston University)	Amherst.
Tuckerman, Frederick (Boston Univ.) .	Boston.
Washburn, John Hosea (Boston Univ.) .	Bridgewater.
Woodbury, Rufus Putnam (Boston Univ.)	Norwalk, Conn.
Total	21

Senior Class.

Dickinson, Richard Storrs (Boston Univ.)	Amherst.
Green, Samuel Bowdlear (Boston Univ.)	Chelsea.
Howard, Joseph Clark	West Bridgewater.
Knox, Reuben	New-York City.
Sherman, Walter Alden (Boston Univ.) .	Lowell.
Smith, George Parmenter (Boston Univ.)	Sunderland.
Swan, Roscoe Willard (Boston Univ.) .	Framingham.
Vaill, William Henry	Enfield.
Waldron, Hiram Edmund Baylies . .	Rochester.
Total	9

[1] The Annual Report, being made in January, necessarily includes parts of two academic years; and the catalogue gives the names of such students as have been connected with the College during any portion of the year 1878.

Junior Class.

Endicott, George	New-York City.
Fowler, Alvan Luther	Westfield.
Gladwin, Frederick Eugene	Westfield.
Hall, Alfred Sigourney	Revere.
Lee, William Gilbert	Amherst.
McQueen, Charles Manjie	Longmeadow.
Parker, William Colverd (Boston University)	Wakefield.
Ripley, George Arms	Worcester.
Rudolph, Charles (Boston University)	New Haven, Conn.
Stone, Almon Humphrey	Phillipston.
Wood, Lewis	West Upton.
Total	11

Sophomore Class.

Brooks, William Cummings	Boston.
Clark, Wallace Valentin	Amherst.
Fairfield, Frank Hamilton	Waltham.
Flint, Charles Louis, jun.	Boston.
Hall, Albert Oliver	Chelsea.
Hills, Joseph Lawrence	Boston.
Hobbs, John Folsom	North Hampton, N.H.
Howe, Elmer Dwight	Marlborough.
Howe, Winslow Brigham	Marlborough.
Perry, Alfred Dwight	Worcester.
Peters, Austin	Boston.
Sattler, Hermann Charles	Baltimore, Md.
Whitaker, Arthur	Needham.
Wilcox, Henry Harrison	Nawiliwili, S.I.
Wolfe, Walter Madson	Montclair, N.J.
Wood, Wilbur	West Upton.
Total	16

Freshman Class.

Abercrombie, Fred Norman	Boston.
Allen, Francis Sherwin	Medfield.
Allen, George Dickinson	Amherst.
Aplin, George Thomas	East Putney, Vt.
Beach, Charles Edward	Hartford, Conn.
Bingham, Eugene Percyval	Fitchburg.

Bishop, William Herbert	Diamond Hill, R.I.
Bowman, Charles Abel	Billerica.
Boynton, Charles Enoch	Groveland.
Brodt, Harry Snowden	Dansville, N.Y.
Brown, Charles Henry	Taunton.
Carr, Walter Frank	Clinton.
Casparian, Gregory	Nicomedia, Turkey.
Chandler, Everett Sawyer	Coldwater, Mich.
Chandler, Willard Mayne	South Natick.
Chapin, Henry Edgerton	Springfield.
Chase, Harry Kirk	Boston.
Chipman, Frank Ellsworth	Beverly.
Clarke, Henry Little	New Bedford.
Clay, Cassius Morey	Westminster, Vt.
Cochran, Robert Armstrong	Maysville, Ky.
Comins, William Henry	North Hadley.
Crafts, George Eben	North Hadley.
Currier, George Francis	Amherst.
Cutter, John Ashburton	Cambridge.
Damon, Samuel Chester	Lancaster.
Delano, Julio Joaquin	Valparaiso, Chili.
Deuel, Frank Dennis	Amherst.
Doyle, John Joseph	Sunderland.
Dutton, Charles Kitteridge	Hatfield.
Fish, Charles Sumner	South Boston.
Floyd, Charles Walter (Boston Univ.)	Boston.
Goodale, David	Marlborough.
Gowdy, Harry Morgan	Westfield.
Harris, Louis Lincoln	Westfield.
Harris, Richard Brown	Boston.
Hashiguchi, Boonzo	Tokio, Japan.
Hillman, Charles Dexter	Hardwick.
Hill, Charles Henry	North Amherst.
Holmes, Samuel Judd	Montclair, N.J.
Howard, Joseph Henry	Hyannis.
Howe, George Dickinson	North Hadley.
Jackson, Andrew	San Francisco, Cal.
Johnson, Frank Prescott	Waltham.
Jones, Edward Spaulding	Worcester.
Jones, Frank Waldo	South Scituate.
Jones, Nathaniel Nelson	Georgetown.
Joyner, Frank Hall	North Egremont.
Kenfield, Charles Robert	Amherst.
Kingman, Morris Bird	Amherst.

Kinney, Burton Arial	Lowell.
Knowles, William Fletcher, jun.	North Cambridge.
Krauss, Alonzo Augustus	Boston.
Leonard, Arthur (Boston University)	Rock.
Livermore, Nathaniel Lyon	Clinton City, Io.
Lindsey, Frank B.	Clayton.
Luques, Edward Childs	Biddeford, Me.
Manton, William James	Line Rock, R.I.
May, Frederick Goddard	Boston.
Meade, William George	Springfield.
Miller, Willie Smith	South Hadley.
Morse, William Austin	Boston.
Myrick, Herbert	Concord.
Paige, James Breckenridge	Prescott.
Parsons, Howard Albert	Enfield, Conn.
Perkins, Charles Brookhouse	Salem.
Perkins, Dana Edson	Lynn.
Plumb, Charles Sumner	Westfield.
Putnam, Henry Anderson	Worcester.
Rawson, Edward Briggs	Brooklyn, L.I.
Rhodes, William Herbert	Boston.
Shiverick, Asa Frank	Wood's Holl.
Smith, Hermann Kellogg	Hadley.
Smith, Hiram Fred Markley	Cleveland, O.
Spalding, Abel Walter	Billerica.
Stone, Winthrop Ellsworth	Amherst.
Taft, Levi Rawson (Boston University)	Mendon.
Taylor, Alfred Howland	Yarmouth.
Taylor, Frederick Patterson	Boston.
Thurston, Wilbur Herbert	Upton.
Warner, Clarence Duane (Boston Univ.)	Granby.
Wheeler, Henry Lewis	Great Barrington.
Wheelock, Victor Lamont	North Amherst.
Wilder, John Emery	Lancaster.
Willard, Daniel	North Hartland, Vt.
Williams, James Stoddard	Glastonbury, Conn.
Wilmarth, Frederick Augustus (Boston University)	Upton.
Windsor, Joseph Libbey	Grafton.
Total	88

Select Class.

Bristol, Frank Edwin	Harwinton, Conn.
Chittenden, Edgar Davis	Sunderland.

Codman, Francis	Brookline.
Courtney, Matthew	Amherst.
Hawley, Amasa Stetson	Hadley.
McKenna, James Peter	Amherst.
Porter, Royal Luther	Brooklyn, L.I.
Smith, Benjamin Salter	New-York City.
Smith, John Leland	Barre.
Warner, William Edward	Newton.
Wing, Edgar Russell	Needham.
Young, Charles Elisha	Amherst.
Zabriskie, Frank Hunter	New-York City.
Total	13

Post-Graduates.

Benson, B. S., David Henry (Boston University)	Bridgewater.
Bragg, B. S., Everett Burt	Amherst.
Clark, B. S., Atherton (Boston Univ.)	Amherst.
Howe, B. S., Charles Sumner (Boston University)	Boston.
Hunt, B. S., John Franklin	Amherst.
Lovell, M. A., Henry Lyman (Amherst College)	Amherst.
Stockbridge, B. S., Horace Edward (Boston University)	Amherst.
Total	7

Summary.

Post-Graduates	7
Graduates of 1878	21
Senior Class	9
Junior Class	11
Sophomore Class	16
Freshman Class	88
Select Class	13
Total	165
Deduct for names inserted twice	3
Total	162

GRADUATES.

Allen, Gideon H., '71, Humboldt, Allen County, Kan., Agent Adams Express Company.

Bagley, David A., '76, Franklin, Brakeman, N. Y. & N. E. R.R.

Baker, David E., '78, Franklin, Travelling Agent.

Barrett, Joseph F., '75, 3 Park Place, New-York City, Travelling Salesman, W. H. Bowker & Co.

Barri, John A., '75, 13 Norfolk Street, Cambridgeport, Clerk, Metropolitan National Bank, Boston.

Bassett, Andrew L., '71, New-York City, Clerk, Vermont C. R.R. & Steamship Co.

Bell, Burleigh C., '72, Arcata, Humboldt County, Cal., Druggist.

Bellamy, John, '76, Brookline, Clerk.

Benedict, John M., '74, Bethel, Conn., Student of Medicine.

Benson, David H., '77, Boston, Superintendent, Fertilizer-Works of W. Bradley & Co.

Birnie, William P., '71, Springfield, Conductor, Conn. Central Railroad.

Blanchard, William H., '74, Westminster, Vt., Farmer.

Boutwell, Willie Levi, '78, Leverett, Farmer.

Bowker, William H., '71, 43 Chatham Street, Boston, Manufacturer and Importer of Fertilizers.

Bragg, Everett B., '75, 43 Chatham Street, Boston, Consulting Chemist, W. H. Bowker & Co.

Brett, William F., '72, Fall River, Merchant.

Brewer, Charles, '77, North Wilbraham, Teacher.

Brigham, Arthur A., '78, Marlborough, Farmer.

Brooks, William P., '75, Sapporo, Japan, Professor of Agriculture, and Farm Superintendent, Agricultural College.

Bunker, Madison, '75, 3 Park Place, New-York City, Dealer in Fertilizers, W. H. Bowker & Co.

Callender, Thomas R., '75, Grantville, Florist.

Campbell, Frederick G., '75, West Westminster, Vt., Farmer.

Caswell, Lilley B., '71, Athol, Civil Engineer and Farmer.

Chandler, Edward P., '74, Abilene, Kan., Farmer.

Chickering, Darius O., '76, Enfield, Farmer.

Choate, Edward C., '78, Cambridge, no business.

Clark, Atherton, '77, Amherst, Post-Graduate, Agric. College.
Clark, John W., '72, Amherst, Nurseryman, Agricultural College.
Clark, Xenos Y., '78, San Francisco, Cal., Teacher.
Clay, Jabez W., '75, 43 Chatham Street, Boston, Dealer in Fertilizers, W. H. Bowker & Co.
Coburn, Charles F., '78, Lowell, Assistant Editor, "Lowell Daily Citizen."
Cowles, Frank C., '72, Amherst, Farmer.
Cowles, Homer L., '71, Hadley, Farmer.
Curtis,[1] Wolfred F., '74.
Cutter, John C., Sapporo, Japan, Professor of Anatomy, Physiology, and Hygiene, Sapporo Agricultural College.
Deuel, Charles F., '76, Amherst, Druggist.
Dodge, George R., '75, 43 Chatham Street, Boston, Superintendent Fertilizer Factory, Brighton, W. H. Bowker & Co.
Dyer, Edward N., '72, Kohala, S.I., Teacher.
Easterbrook, Isaac H., '72, Diamond Hill, R.I., Farmer.
Eldred, Frederick C., '73, New-York City, Insurance Agent.
Ellsworth, Emory A., '71, Ashfield, Farmer.
Fisher, Jabez F., '71, Fitchburg, Local Freight Cashier, Fitchburg Railroad.
Fiske, Edward R., '72, Philadelphia, Penn., Merchant, Folwell & Brothers.
Flagg, Charles O., '72, Diamond Hill, R.I., Farmer.
Foote, Sandford D., '78, Springfield, no business.
Fuller, George E., '71, Greenfield, Civil Engineer.
Grover, Richard B., '72, Andover, Student of Theology.
Guild, George W. M., '76, Boston, no business.
Hague, Henry, '75, Manville, R.I., Clergyman.
Hall, Josiah N., '78, Revere, Medical Student, Harvard University.
Harwood, Peter M., '75, Barre, Farmer.
Hawley, Frank W., '71, Trucking business, F. Hamlin.
Hawley, Joseph M., '76, Berlin, Wis., Banker's Clerk.
Herrick, Frederick St. C., '71, Methuen, Farmer.
Hibbard, Joseph R., '77 Stoughton, Wis., Farmer.
Hitchcock, Daniel G., '74, Warren, Merchant.
Hobbs, John A., '74, Bloomington, Neb., Farmer.
Holmes, Lemuel LeB., '72, Mattapoisett, Lawyer.
Howe, Charles S., '78, Amherst, Post-Graduate, Agric. College.
Howe, Waldo V., '77, Framingham, Clerk, Framingham Brick Co.
Hubbard, Henry F., '78, 93 Duane Street, New-York City, Office, James E. Halsey.

[1] Died Nov. 8, 1878, of inflammation of the brain.

Hunt, John F., '78, Amherst, Post-Graduate, Agricultural College.
Kendall, Hiram, '76, Providence, R.I., Chemist and Superintendent, Kendall Manufacturing Company.
Kimball, Francis E., '72, Worcester, Clerk, B. B. & G. R.R.
Knapp, Walter H., '75, Grantville, Florist.
Koch, Henry G. H., '78, Wurmdorf, Hanover, Germany, Farmer.
Ladd, Thomas H., '76, Boston, Student.
Lee, Lauren K., '75, Grinnell, Io., Hotel Clerk.
Leland, Walter S., '73, Sherborn, Farmer.
Leonard, George, '71, Springfield, Lawyer.
Libby, Edgar H., '74, New-York City, Editor, "American Agriculturist."
Livermore, Russell W., '72, Toledo, O., Lawyer, firm of Bissell & Gorrill.
Lovell, Charles O., '78, Amherst, Photographer.
Lyman, Asahel H., '73, Manistee, Mich., Druggist.
Lyman, Charles E., '78, Middlefield, Conn., Farmer.
Lyman,[1] Henry, '74.
Lyman, Robert W., '71, Boston, Law Student, Boston University.
Mackie, George, '72, Attleborough, Physician.
Macleod, William A., '76, Boston, Student of Law, Boston University, Office of Dana & Harding.
Mann, George H., '76, Sharon, Manufacturer.
Martin, William E., '76, Clerk, Excelsior, Minn.
Maynard, Samuel T., '72, Amherst, Assistant Professor Horticulture, Agricultural College.
McConnel, Charles W., '76, Woonsocket, R.I., Student of Dentistry.
Miles, George M., '75, Miles City, Montana, Judge U. S. Comm. and Raiser of Sheep.
Mills, George W., '73, Medford, Physician.
Minor, John B., 73, New Britain, Conn., Clerk, Union Mfg. Co.
Montague, Arthur H., '74, South Hadley, Farmer.
Morey, Herbert E., '72, 49 Haverhill Street, Boston, Clerk, Morey & Smith.
Morse, James H., '71, Salem, Civil Engineer.
Myrick, Lockwood, '78, Concord, Law Student, Office, Hon. E. R. Hoar, Boston.
Nichols, Lewis A., '71, Chelsea, Civil Engineer.
Norcross, Arthur D., '71, Monson, Farmer.
Nye, George E., 77, Sandwich, Farmer.
Osgood, Frederick H., '78, Edinburgh, Scotland, Student of Veterinary.

[1] Died Jan. 8, 1879, of pneumonia, at Middlefield, Conn.

Otis, Harry P., '75, Leeds, Supt., Northampton Emery Wheel Co.
Page, Joel B., '71, Conway, Farmer.
Parker, George A., '76, Poughkeepsie, N.Y., Gardener, Vassar Coll.
Parker, George L., '76, Dorchester, Florist.
Parker, Henry F., '77, Bristol, R.I., Draughtsman.
Peabody, William R., '72, Atchison, Kan., General Agent, A. T. & S. F. R.R.
Penhallow, David P., '73, Sapporo, Japan, Professor of Chemistry and Botany, Agricultural College.
Phelps, Charles H., '76, South Framingham, Florist.
Phelps, Henry L., '74, Northampton, Dealer in Fertilizers.
Porter, William H., '76, Hatfield, Farmer.
Porto, Raymundo M. da S., '77, Para, Brazil, Planter.
Potter, William S., '76, LaFayette, Ind., law firm of W. D. Wallace.
Renshaw, James B., '73, Oberlin, O., Student of Theology.
Richmond, Samuel H., '71, Boston, Professor of Penmanship, French's Business College.
Rice, Frank H., '75, Aurora, Nev., Clerk.
Root, Joseph E., '76, Hartford, Conn., Assistant Superintendent, Walnut Hill Asylum.
Russell, William D., '71, Turner's Falls, Chemist.
Salisbury, Frank B., '72, Diamond Fields, South Africa, Clerk.
Sears, John M., '76, Ashfield, Farmer.
Shaw, Elliot D., '72, Holyoke, Florist.
Simpson, Henry B., '73, Centreville, Md., Farmer.
Smead, Edwin, '71, 83 Edmonson Avenue, Baltimore, Md., Dealer in Coal.
Smith, Frank S., '74, Hampden, Woollen Manufacturer.
Smith, Thomas E., '76, West Chesterfield, Manufacturer.
Snow, George H., '72, Leominster, Farmer.
Somers, Frederick M., '72, San Francisco, Cal., Editor "Argonaut."
Southmayd,[1] John E., '77.
Southwick, Andre A., '75, Amherst, Farm Supt., Agric. College.
Sparrow, Lewis A., '71, 43 Chatham Street, Boston, Chemist, W. H. Bowker & Co.
Spofford, Amos L., '78, Georgetown, Student of Medicine, Harvard University.
Stockbridge, Horace E., '78, Amherst, Post-Graduate, Agric. Coll.
Strickland, George P., '71, Stillwater, Mich., Machinist, Seymour, Sabin, & Company.
Taft, Cyrus A., '76, Whitinsville, Machinist.

[1] Died Dec. 11, 1878, of consumption, at Minneapolis, Minn.

Thompson, Edgar E., '71, Brockton, Druggist.
Thompson, Samuel C., '72, Natick, Civil Engineer.
Tucker, George H., '71, Dakota, Farmer and Sheep-Raiser.
Tuckerman, Frederick, '78, Tunbridge Wells, Eng., travelling in Europe.
Urner, George P., '76, 54 Leonard Street, New-York City, Superintendent, American Ruffle-Works.
Wakefield, Albert T., '73, Peoria, Ill., Physician.
Ware, Willard C., '71, 32 North Street, Boston, Salesman, Oak Hall.
Warner, Seth S., '73, San Francisco, Cal., Clerk.
Washburn, John H., '78, North Raynham, Teacher.
Webb, James H., '73, New Haven, Conn., Attorney-at-Law.
Wellington, Charles, '73, Washington, D.C., Chemist, U. S. Agricultural Department.
Wells, Henry, '72, Rochester, N.Y., Clerk.
Wetmore, Howard G., '76, New-York City, Student of Medicine.
Wheeler, William, '71, Sapporo, Japan, Pres. Agric. College.
Whitney, Frank LeP., '71.
Whitney, William C., '72, Boston, Architect.
Williams, John E., '76, Amherst, Editor, "Record."
Winchester, John F., '75, Lawrence, Veterinary Surgeon.
Wood, Frank W., '73, Providence, R.I., Civil Engineer.
Woodbury, Rufus P., '78.
Woodman, Edward E., '74, Jersey City, N.J., Florist, Peter Henderson.
Wyman, Joseph, '77, Arlington, Farmer.
Zeller, Harrie McK., '74, Hagerstown, Md., Farmer.

COURSE OF STUDY AND TRAINING.

FRESHMAN YEAR.

First Term. — Chemistry, 5 hours each week; Human Anatomy, Physiology, and Hygiene, 3 hours; Algebra, 5 hours; English, 2 hours; Agriculture, 2 hours; Declamation, 1 hour; Military Drill, 4 hours; Manual Labor, 6 hours.

Second Term. — Inorganic Chemistry, 2 hours; Botany, 3 hours; Geometry, 5 hours; Agriculture, 3 hours; English, 2 hours; Elocution, 1 hour; Freehand Drawing, 3 hours; Military Drill, 3 hours.

Third Term. — Systematic Botany, 4 hours; Geometry, 4 hours; French, 5 hours; Elocution, 2 hours; Agriculture, 2 hours; Military Drill, 4 hours; Manual Labor, 6 hours.

SOPHOMORE YEAR.

First Term. — Systematic Botany, 3 hours each week; Geometry, 4 hours; French, 5 hours; English, 1 hour; Agriculture, 2 hours; Declamation, 1 hour; Military Drill, 4 hours; Manual Labor, 6 hours.

Second Term. — Geology, 3 hours; Trigonometry, 5 hours; French, 4 hours; English, 1 hour; Agriculture, 3 hours; Declamation, 1 hour; Drawing, 3 hours; Military Drill, 3 hours;

Third Term. — Zoölogy, 5 hours; Surveying, 5 hours; Agriculture, 2 hours; English, 3 hours; Declamation, 1 hour; Levelling, 3 hours; Military Drill, 4 hours; Manual Labor, 6 hours.

JUNIOR YEAR.

First Term. — German, 5 hours each week; Mechanics, 5 hours; Entomology, 2 hours; Market-Gardening, 2 hours; Horticulture, 2 hours; Military Drill, 3 hours; Manual Labor, 6 hours.

Second Term. — German, 4 hours; Physics, 5 hours; Practical Chemistry, 9 hours; Drawing, 3 hours; Agricultural Debate, 1 hour; Declamation, 1 hour; Military Drill, 3 hours.

Third Term. — German, 4 hours; Astronomy, 4 hours; Practical Chemistry, 9 hours; Declamation, 1 hour; Stock and Dairy Farming, 2 hours; Military Drill, 4 hours; Manual Labor, 6 hours.

SENIOR YEAR.

First Term. — English Literature, 4 hours each week; Practical Chemistry, 7 hours; Book-keeping, 2 hours; Roads and Railroads, 3 hours; Military Science, 2 hours; Original Declamation, 1 hour; Military Drill, 3 hours.

Second Term. — English Literature, 4 hours; Theses, 1 hour; Mental Science, 4 hours; Agriculture, 2 hours; Veterinary Science, 3 hours; Military Science, 2 hours; Microscopy, 4 hours; Military Drill, 3 hours.

Third Term. — Veterinary Science, 2 hours; Military Science, 2 hours; Botany, 3 hours; Landscape-Gardening, 3 hours; Rural Law, 1 hour; Lectures on English Language, 2 hours; Theses, 1 hour; Agricultural Review, 4 hours; Military Drill, 4 hours.

LIST OF BOOKS.

BOTANY AND HORTICULTURE.

Gray's Lessons, Manual and Botanical Text-Book.
Sachs' Text-Book of Botany, Morphological and Physiological.
Masters' Henfrey's Elementary Course of Botany.
Berkeley's Introduction to Cryptogamic Botany.
Cooke's Microscopic Fungi.
Carpenter's The Microscope and its Revelations.
Flint's Grasses and Forage-Plants.
Downing's Fruits and Fruit-Trees of America.
Thomas's American Fruit-Culturist.
Hoope's Book of Evergreens.
Strong's Grape-Culture.
Henderson's Practical Floriculture.
Fuller's Forest-Tree Culturist.
Williams's Choice Stove and Greenhouse Plants.
Helmsley's Hand-Book of Hardy Trees, Shrubs, and Herbaceous Plants.
Loudon's Cyclopædia of Plants.
Loudon's Cyclopædia of Gardening.
Lindley and Moore's Treasury of Botany.
Kemp's Landscape-Gardening.
Downing's Landscape-Gardening.

AGRICULTURE.

Johnson's How Crops Grow.
Johnson's How Crops Feed.
Pendleton's Scientific Agriculture.

Hyde's Lowell Lectures on Agriculture.
Liebig's Natural Laws of Husbandry.
French's Farm Drainage.
Flint's Milch Cows and Dairy Farming.
Sturtevant's, The Dairy Cow, — Ayrshire.
Waring's Handy-Book of Husbandry.
Henderson's Gardening for Profit.
Donaldson's British Agriculture.
Morton's Cyclopædia of Agriculture.
Low's Domesticated Animals.
Flint's Reports on the Agriculture of Massachusetts.
Agricultural Gazette and Gardener's Chronicle, London, Eng.

CHEMISTRY AND GEOLOGY.

Bolton's Hooker's Chemistry.
Watt's Fownes's Manual of Elementary Chemistry.
Sibson's Agricultural Chemistry.
Caldwell's Agricultural Chemical Analysis.
Smith's Classen's Quantitative Analysis.
Nason's Woehler's Chemical Analysis.
Will's Analytical Chemistry.
Johnson's Fresenius' Qualitative and Quantitative Analysis.
Liebig's Ernährung der Pflanzen.
Wolff's Landwirthschaftliche Analyse.
Hoffman's Ackerbau Chemie.
Watt's Chemical Dictionary.
Dana's Mineralogy.
Hitchcock's Geology.
Dana's Text-Book and Manual of Geology.

VETERINARY SCIENCE AND ZOÖLOGY.

Fleming's Chauveau's Comparative Anatomy of Domesticated Animals.
Dalton's Human Physiology.
Cleland's Animal Physiology.
Williams's Principles of Veterinary Surgery.
Williams's Principles of Veterinary Medicine.
Gamgee's On Horse-shoeing and Lameness.
Gamgee's On Domestic Animals in Health and Disease.
Armitage's Clater's Cattle Doctor.
Youatt's Treatises on the Domestic Animals.
Blaine's Veterinary Art.
Morton's Manual of Pharmacy.
Wood and Bache's United-States Dispensatory.

Harbison's Elementary Zoölogy.
Lankester's Advanced Zoölogy.
Packard's Guide to the Study of Insects.
Harris's Insects Injurious to Vegetation.
Westwood's Principles of Classification of Insects.
Baird's Mammals of North America.
Murray's Geographical Distribution of Mammals.
Samuels's Birds of New England.
Cobbold's Entozoa.
Denney's Parasitic Insects.
Moquin-Tandon's Manual of Medical Zoölogy.

MATHEMATICS, PHYSICS, AND CIVIL ENGINEERING.

Wells's Algebra.
Loomis's Geometry and Conic Sections.
Murray's Land-Surveying.
Greenleaf's Trigonometry.
Gilmore's Roads and Railroads.
Hill's Stewart's Natural Philosophy.
Everett's Deschanel's Natural Philosophy.
Atkinson's Ganot's Physics.
Peabody's Astronomy.
Loomis's Meteorology.

ENGLISH, FRENCH, AND GERMAN.

Hart's Composition.
Fowler's English Grammar.
Shaw's Complete Manual of English Literature.
Chambers's Cyclopædia of English Literature.
Morley's English Writers.
Taine's History of English Literature.
Languillier and Monsanto's French Grammar.
Spiers and Surenne's French Dictionary.
Glaubensklee's German Grammar.
Adler's German Dictionary.

The French and German books for translation are changed every year, selections being made from recent literary and scientific publications.

MENTAL, MORAL, AND SOCIAL SCIENCE.

Haven's Mental Science.
Hickok's Empirical Psychology.
Porter's Elements of Intellectual Science.
Seelye's Schwegler's History of Philosophy.

Hickok's Moral Science.
Haven's Moral Philosophy.
Hopkins's Law of Love, and Love as Law.
Chadbourne's Natural Theology.
Walker's Science of Wealth.
Perry's Political Economy.
Carey's Principles of Social Science.
Stirling's Bastiat's Harmonies of Political Economy.

MILITARY SCIENCE.

Lippitt's Tactical Use of the Three Arms.
Lippitt's Treatise on Intrenchments.
Lippitt's Field Service in Time of War.
Lippitt's Special Operations of War.
Welcker's Military Lessons.
Upton's Infantry Tactics.
United-States Artillery Tactics.
Kent's Commentaries.
Benet's Courts-Martial.
Holt's Digest of Opinions.
Halleck's International Law.
Regulations of United-States Army.
United-States Ordnance Manual.
General and State Militia and Volunteer Laws.
Scott's Military History.
Histories of Revolution, War of 1812, Mexican War, and Rebellion.
Public Documents, and Reports of Naval and Military Departments.

CALENDAR FOR 1879.

The third term of the collegiate year begins March 27, and continues till June 25.

The first term begins Aug. 28, and continues till Nov. 27.

The second term begins Dec. 11, and continues till March 11, 1880.

There will be an examination of candidates for admission to the College, at the Botanic Museum, at nine A.M., Tuesday, June 24, and also on Thursday, Aug. 28.

The Farnsworth Prize Declamations take place Monday evening, June 23.

The public examination of the graduating class for the Grinnell Prize for excellence in agriculture, and the examination of the

other classes in the studies of the term, will take place on Tuesday forenoon, June 24.

The exercises of Graduation Day occur June 25.

ADMISSION.

Candidates for admission to the Freshman Class are examined, orally and in writing, upon the following subjects: English Grammar, Geography, Arithmetic, Algebra through simple equations, and the History of the United States.

Candidates for higher standing are examined as above, and also in the studies gone over by the class to which they may desire admission.

No one can be admitted to the College until he is fifteen years of age; and every student is required to furnish a certificate of good character from his late pastor or teacher, and to give security for the prompt payment of term-bills. Tuition and room-rent must be paid in advance, at the beginning of each term; and bills for board, fuel, &c., at the end of every term.

The regular examinations for admission are held at the Botanic Museum, at nine o'clock A.M., Tuesday, June 24, and on Thursday, Aug. 28; but candidates may be examined and admitted at any other time in the year.

EXPENSES.

Tuition	$25 00 per term.
Room-rent	5 00 to 10 00 "
Board	2 50 to 3 50 per week.
Expenses of chemical laboratory to students of practical chemistry	10 00 per term.
Public and private damages, including value of chemical apparatus destroyed or injured,	at cost.
Annual expenses, including books	250 00 to 350 00.

REMARKS.

The regular course of study occupies four years; and those who complete it receive the degree of Bachelor of Science, the diploma being signed by the Governor of Massachusetts, who is president of the corporation.

Regular students of the College may also, on application, become members of Boston University, and upon graduation receive

its diploma in addition to that of the College, thereby becoming entitled to all the privileges of its alumni.

The instruction in the languages is intended to qualify the graduates to write and speak English with correctness and effect, and to translate German and French with facility. The scientific course is as thorough and practical as possible, and every science is taught with constant reference to its application to agriculture and the wants of the farmer.

The instruction in agriculture and horticulture includes every branch of farming and gardening which is practised in Massachusetts, and is both theoretical and practical. Each topic is discussed thoroughly in the lecture-room, and again in the plant-house or field, where every student is obliged to labor. The amount of required work, however, is limited to six hours per week, in order that it may not interfere with study. Students are allowed to do additional work for wages, provided they maintain the necessary rank as scholars.

Indigent students are allowed to do such work as may offer about the College or farm buildings, or in the field; but it is hardly possible for one to earn more than from fifty to one hundred dollars per annum besides performing other duties. So far as is consistent with circumstances, students will be permitted to select such varieties of labor as they may for special reasons desire to engage in.

Those who pursue a select course attend recitations and lectures with the regular classes; but those properly qualified, who desire special instruction in botany, chemistry, civil engineering, veterinary science, agriculture or horticulture, may make private arrangements with the officers having charge of these departments.

An expenditure of from ten to fifty dollars is necessary to provide furniture, which may be purchased at reasonable rates, either new or second-hand. At the beginning of the second term of attendance each student is required to provide himself with the full uniform prescribed for the battalion of Agricultural Cadets, the cost of which is about thirty dollars.

On Sundays students are required to attend church in the forenoon, and invited to join a class for the study of the Bible in the afternoon. They will be permitted to select their place of attendance from among the churches in the town, of the following denominations; viz., Baptist, Congregational, Episcopalian, Methodist, and Roman-Catholic.

POST-GRADUATE COURSE.

Graduates of colleges and scientific schools may become candidates for the degree of Doctor of Science, or Doctor of Philosophy, from the College or from the University, and pursue their studies under the direction of Professor Goessmann in chemistry, or other members of the faculty in their respective departments.

BOOKS, APPARATUS, AND SPECIMENS IN NATURAL HISTORY.

The Library of the College contains about fifteen hundred volumes. Among them are several valuable sets of cyclopædias, magazines, and newspapers, reports of agricultural societies and state boards of agriculture, and many standard works on agriculture and horticulture. There are also many useful works of reference in chemistry, botany, surveying, and drawing.

The faculty and students also have the privilege of drawing books from the excellent library of Amherst College, which contains over thirty thousand volumes.

The State Cabinet of specimens, illustrating the geology and natural history of Massachusetts, has been removed from Boston to the College, and is of much value for purposes of instruction.

The Knowlton Herbarium contains more than ten thousand species of named botanical specimens, besides a large number of duplicates. The Botanic Museum is supplied with many interesting and useful specimens of seeds, woods, and fruit-models. There is also a set of diagrams illustrating structural and systematic botany, including about three thousand figures.

About fifteen hundred species and varieties of plants are cultivated in the Durfee Plant-House, affording much pleasure and information to students and visitors.

The very extensive, and in some respects unsurpassed, collections in geology, mineralogy and natural history, ethnology and art, belonging to Amherst College, are accessible to members of the Agricultural College.

The chemical, engineering, and military departments of the Agricultural College are well furnished.

The class in microscopy has the use of seven of Tolles's best compound microscopes, with objectives from four inches to one-eighth of an inch in focal distance, and a variety of eye-pieces.

PRIZES.

FARNSWORTH RHETORICAL MEDALS.

Isaac D. Farnsworth, Esq., of Boston, has generously provided a fund of fifteen hundred dollars, which is to be used for the purchase of gold and silver medals, to be annually awarded, under the direction of the College Faculty, for excellence in Declamation.

GRINNELL AGRICULTURAL PRIZES.

Hon. William Claflin of Boston has given the sum of one thousand dollars for the endowment of a first prize of fifty dollars, and a second prize of thirty dollars, to be called the Grinnell Agricultural Prizes, in honor of George B. Grinnell, Esq., of New York. These prizes are to be paid in cash to those two members of the graduating class who may pass the best oral and written examination in Theoretical and Practical Agriculture.

HILLS BOTANICAL PRIZES.

For the best Herbarium collected by a member of the class of 1879, a prize of fifteen dollars is offered, and, for the second best, a prize of ten dollars; also a prize of five dollars for the best collection of woods, and a prize of five dollars for the best collection of specimens of dried plants, from the College Farm.

TOTTEN MILITARY PRIZE.

For the best Essay by a member of the Senior class on such topic as may be assigned, a prize of twenty-five dollars is offered.

Subject for 1879, "The Sword and the Plough."

REGULATIONS.

I. — Students are forbidden to combine together for the purpose of absenting themselves from any required exercise, or violating any known regulation of the College.

II. — The roll shall be called five minutes after the ringing of the bell for each exercise of the College, by the officer in charge, unless a monitor be employed; and students who do not answer to their names shall be marked absent, provided that any student coming in after his name has been called shall be marked tardy. Two tardinesses shall be reckoned as one absence.

III. — Absence from a single exercise may be alloweed or excused

by the officer in charge of the same, if requested beforehand; but permission to be absent from several exercises must be obtained in advance from the general excusing officer, or from the president. In such cases the officer excusing will furnish a certificate of excuse, which shall state the precise time for which absence is permitted, and which shall be a satisfactory reason for absence from all exercises occurring within the time specified.

IV. — Excuses for all absences, whether with permission obtained beforehand or not, must be submitted to the excusing committee. They must be rendered promptly within one week from the date of absence; and those deemed unsatisfactory will be returned to the student with the indorsement of the committee.

V. — Whenever the aggregate number of unexcused absences in all departments reaches five, the student so delinquent shall be informed of the fact. When the number of such absences reaches eight, the parent or guardian of the student shall be informed of his delinquency; and, when ten such delinquencies are justly recorded against any student, his connection with the College may be terminated.

VI. — Students are forbidden to absent themselves without excuse from the regular examinations, to give up any study without permission from the president, or to remove from one room to another without authority from the officer in charge of the dormitory buildings; and no student shall be permitted to make such change until he has procured from the inspecting officer a written statement that the room about to be vacated is in perfect order.

VII. — Students shall be required to attend the church of their selection regularly on Sunday morning, and report in writing to the excusing officer, during the ensuing week, whether they attended or not.

VIII. — The record of deportment, scholarship, and attendance, will be carefully kept; and, whenever the average rank of a student falls below fifty, he will not be allowed to remain a member of the College except by a special vote of the faculty. Admission to the College, and promotion from class to class, as well as to graduation, are granted only by vote of the faculty.

IX. — Students are required to abstain from any thing injurious to the buildings and other property of the College, and in all respects to conduct themselves with propriety.

X. — Parents and guardians are specially urged to co-operate with the faculty in securing the faithful attendance of students upon every appointed exercise of the College.

SIZE OF ROOMS.

For the information of those desiring to carpet their rooms, the following measurements are given. In the south dormitory the main corner-rooms are fifteen by eighteen feet, and the adjoining bedrooms eight by twelve feet. The inside rooms are fourteen by fifteen feet, and the bedrooms eight by eight feet. In the north dormitory the corner-rooms are fourteen by fifteen feet, and the annexed bedrooms eight by ten feet; while the inside rooms are thirteen feet and a half by fourteen feet and a half, and the bedrooms eight by eight feet.

SCHOLARSHIPS.

The Massachusetts Society for Promoting Agriculture pays annually into the treasury of the College the sum of three hundred dollars, which is assigned by the faculty to the payment of the tuition of four worthy indigent students who intend to engage in agricultural pursuits after graduation.

The income of the Robinson Fund of one thousand dollars, the bequest of Miss Mary Robinson of Medfield, is assigned by the faculty to such indigent student as they may deem most worthy.

The Trustees voted in January, 1878, to establish one free scholarship for each of the eleven congressional districts of the State. Applications for such scholarships should be made to the representative from the district to which the applicant belongs. The selection for these scholarships will be determined as each member of Congress may prefer; but, where several applications are sent in from the same district, a competitive examination would seem to be desirable. Applicants should be good scholars, of vigorous constitution; and should enter College with the intention of remaining through the course, and then engaging in some pursuit connected with agriculture. To every such student the cash value of a scholarship is three hundred dollars.

FINANCIAL STATEMENT, JAN. 1, 1879.

REAL ESTATE.

College Farm and Quarry	$37,500 00
North College	36,000 00
South College	36,000 00
College Hall	30,000 00
South Boarding-House	8,000 00
North Boarding-House	8,000 00
Durfee Plant-House	12,000 00
Botanic Museum	5,000 00
South Barn	14,500 00
Farm-House	4,000 00
Four Dwellings and Barns purchased with the Estate,	9,000 00
Total Real Estate, Cost	$200,000 00

FARM STATEMENT.

Value of Live-Stock	$4,470 00
Vehicles and Implements	1,246 00
Produce on Hand	1,617 50

FUND FOR MAINTENANCE OF COLLEGE, IN CHARGE OF THE STATE TREASURER.

Agricultural College Fund.

Cash Balance on hand Jan. 1, 1879		$71,000 00
Present investments, —		
City of Lynn Bonds	$25,000 00	
Chelsea Note	25,000 00	
Town of Milford Bonds	14,200 00	
Hudson Note	35,000 00	
Brighton Note	10,000 00	

Town of Milton Note	$10,000 00	
Plymouth Note	6,724 65	
West-Roxbury Note	30,000 00	
Westborough Note	12,000 00	
Lee Note	4,142 75	
Somerset Note	10,000 00	
County of Hampden Notes	75,000 00	
		$257,067 40
Massachusetts, Troy, and Greenfield Railroad Bonds	$8,000 00	
Massachusetts Bonds	20,000 00	
		28,000 00
Maine Bonds		4,000 00
Total Fund		$360,067 40

Two-thirds of the income of this fund is by law paid to the Treasurer of the College, and one-third to the Treasurer of the Institute of Technology.

The Hills Fund of ten thousand dollars, for the maintenance of the Botanic Garden, is in charge of the College Treasurer.

To this sum should be added the receipts for tuition and room-rent, and the receipts from the sale of the products of the farm and garden.

Summary Statement of all Income and Receipts on Account of the Massachusetts Agricultural College, from its Incorporation in 1863, to Jan. 1, 1879.

	1864-66.	1867.	1868.	1869.	1870.	1871.
Balance	–	–	$4,485 83	–	–	–
Income from Agricultural College Fund	–	$10,930 00	8,908 10	$9,035 52	$4,839 82	$12,364 22
State Appropriations	$20,000 00	–	50,000 00	50,000 00	25,000 00	50,000 00
Received for $\frac{1}{10}$ Land Scrip	29,778 40	–	–	–	–	–
Dr. N. Durfee for Plant-House	–	10,000 00	–	–	–	–
Town of Amherst and Friends	–	60,156 67	–	–	–	–
Farm Account	–	2,030 22	2,204 16	1,840 06	3,004 78	633 01
Amherst College and Friends	–	–	12,343 33	–	2,500 00	–
Income of Hills Fund	–	–	500 00	500 00	500 00	500 00
Bills Payable	–	–	11,000 00	–	–	–
Term Bills	–	–	7,620 87	11,554 38	13,204 56	12,932 65
Botanical Department	–	–	107 28	–	–	106 69
Contingent Fund	–	–	–	119 10	281 78	153 88
Interest on Deposits	–	–	–	–	–	–
Insurance	–	–	–	–	–	–
Mary Robinson Fund	–	–	–	–	–	–
Farnsworth Prize Fund	–	–	–	–	–	–
Grinnell Prize Fund	–	–	–	–	–	–
Income Grinnell Fund	–	–	–	–	–	–
Totten Military Prize Fund	–	–	–	–	–	–
Total	$49,778 40	$83,116 89	$97,169 57	$73,049 06	$49,330 94	$76,690 45

Summary Statement of all Income and Receipts on Account of the Massachusetts Agricultural College, from its Incorporation in 1863, to Jan. 1, 1879. — Concluded.

	1872.	1873.	1874.	1875.	1876.	1877.	1878.
Balance	–	–	–	–	–	–	–
Income from Agricultural College Fund	$15,083 07	$14,982 91	$15,701 75	$15,459 00	$15,178 66	$14,985 47	$13,064 28
State Appropriations	–	–	18,000 00	–	5,000 00	3,665 90	1,334 10
Received for $\frac{1}{10}$ Land Scrip	–	–	–	–	–	–	–
Dr. N. Durfee for Plant-House	–	–	–	–	–	–	–
Town of Amherst and Friends	–	–	–	–	–	–	–
Farm Account	873 50	2,107 69	1,487 54	1,637 12	1,722 64	2,073 76	1,506 78
Amherst College and Friends	–	–	–	–	–	–	–
Income of Hills Fund	500 00	500 00	500 00	500 00	500 00	500 00	500 00
Bills Payable	–	10,460 00	3,500 00	4,000 00	20,690 42	24,500 00	6,000 00
Term Bills	10,386 02	9,395 51	9,892 92	13,107 28	11,090 06	7,865 88	8,140 25
Botanical Department	724 95	580 59	549 20	955 80	1,089 41	2,066 02	1,644 59
Contingent Fund	–	90 59	190 60	9 84	37 82	661 74	409 33
Interest on Deposits	390 00	–	140 00	–	–	–	–
Insurance	1,501 63	–	–	–	–	–	–
Mary Robinson Fund	–	–	1,000 00	–	–	–	35 00
Farnsworth Prize Fund	–	–	90 00	100 00	100 00	100 00	100 00
Grinnell Prize Fund	–	–	1,000 00	–	–	–	–
Income Grinnell Fund	–	–	100 00	80 00	80 00	80 00	80 00
Totten Military Prize Fund	–	–	–	–	–	–	3 00
Total	$29,459 17	$38,117 29	$52,152 01	$35,849 04	$55,489 01	$57,044 60	$32,640 08

Summary Statement of all Payments and Expenditures on Account of the Massachusetts Agricultural College, from its Incorporation in 1863, to Jan. 1, 1879.

	1864-66.	1867.	1868.	1869.	1870.	1871.
Salaries	–	$9,250 00	$5,250 00	$12,459 72	$16,389 92	$15,016 67
Land and Buildings	$32,499 50	–	6,000 00	7,000 00	–	–
Building Fund	–	53,290 94	51,352 15	31,419 71	11,006 29	3,711 45
Current Expenses	8,955 26	17,824 93	9,686 23	13,640 96	6,102 51	13,184 02
Farm Expenses	–	11,074 66	3,467 71	6,253 18	6,116 77	6,337 83
Bills Payable	–	–	–	–	–	11,000 00
Interest	–	–	365 67	1,379 20	1,138 31	385 00
Income of Hills Fund paid out	–	–	450 92	281 44	30 00	269 97
Term Bill Expenses, and Laboratory Account	–	–	1,394 83	4,644 62	4,519 61	3,155 59
Board of Students	–	–	4,447 36	5,672 27	4,746 61	6,833 55
Botanical Department	–	–	–	65 86	121 66	607 90
Extra Instruction	–	–	–	–	1,893 25	1,445 00
Investment of Grinnell Prize Fund	–	–	–	–	–	–
Grinnell Agricultural Prizes	–	–	–	–	–	–
Farnsworth Rhetorical Prizes	–	–	–	–	–	–
Indebtedness paid	–	–	–	–	–	–
	$41,454 76	$91,440 53	$82,414 77	$82,816 96	$52,064 93	$61,946 98

Summary Statement of all Payments and Expenditures on Account of the Massachusetts Agricultural College, from its Incorporation in 1863, to Jan. 1, 1879. — Concluded.

	1872.	1873.	1874.	1875.	1876.	1877.	1878.
Salaries	$17,705 00	$19,540 89	$19,995 83	$18,272 50	$19,032 50	$16,350 00	$13,693 20
Land and Buildings	–	–	–	–	–	–	–
Building Fund	–	–	–	–	–	–	–
Current Expenses	9,656 29	6,556 49	12,755 16	6,866 96	5,084 35	4,581 35	3,117 15
Farm Expenses	7,313 54	4,548 55	4,222 24	3,495 00	5,180 02	3,669 80	2,574 64
Bills Payable	–	–	3,960 00	–	14,690 42	23,500 00	3,000 00
Interest	–	371 16	684 02	1,079 92	822 80	1,636 24	1,381 66
Income of Hills Fund paid out	916 42	725 73	509 04	252 04	416 43	240 97	1,010 24
Term Bill Expenses, and Laboratory Account	2,031 13	2,315 12	1,263 99	3,142 83	2,174 14	2,561 86	3,053 34
Board of Students	4,249 51	4,281 82	3,851 97	4,773 27	3,790 37	1,795 19	3,368 56
Botanical Department	364 38	274 75	473 96	1,117 35	915 39	2,103 75	1,628 65
Extra Instruction	846 00	–	400 00	664 38	–	–	–
Investment of Grinnell Prize Fund	–	–	1,000 00	–	–	–	–
Grinnell Agricultural Prizes	–	–	117 00	70 00	70 00	70 00	70 00
Farnsworth Rhetorical Prizes	–	–	70 00	117 00	100 00	100 00	100 00
Indebtedness paid	–	–	–	–	3,232 12	–	–
	$43,082 27	$38,614 51	$49,303 21	$39,851 25	$55,508 54	$56,609 16	$33,017 34

Summary Statement of all Income and Receipts and all Payments and Expenditures on Account of the Massachusetts Agricultural College, from its Incorporation in 1863, to Jan. 1, 1879.

Income and Receipts.		Payments and Expenditures.	
Balance, Jan. 1, 1868	$4,485 83	Salaries	$182,956 23
From Income from Agricultural College Fund	150,532 80	Land and Buildings	45,499 50
State Appropriations	223,000 00	Building Fund Account	150,780 54
One-tenth Land Scrip for Purchase of Farm	29,778 40	Current Expense Account	118,011 66
Dr. Nathan Durfee for Plant-House	10,000 00	Farm Account [1]	64,253 94
Town of Amherst and Friends	75,000 00	Bills Payable	56,150 42
Farm Account	21,121 26	Interest Account	9,243 88
Income of Hills Fund	5,868 58	Income of Hills Fund, expended	5,103 20
Bills Payable	80,150 42	Term Bill Account	30,257 06
Term Bill Account	115,189 38	Board of Students	47,810 48
Botanical Department	7,824 53	Botanical Department	7,673 65
Contingent Fund	1,954 68	Extra Instruction and Lectures	5,248 63
Interest on Deposits	530 00	Grinnell Prize Fund Investment	1,000 00
Insurance	1,501 63	Income Grinnell Prize Fund, expended	417 00
Bequest of Miss Mary Robinson	1,000 00	Income Farnsworth Prize Fund, expended	487 00
Income of Miss Mary Robinson Fund, unexpended	35 00	Mary Robinson Fund Investment	1,000 00
Farnsworth Prize Fund	490 00	Indebtedness, paid 1876	3,232 12
Grinnell Prize Fund	1,000 00		$729,125 31
Income of Grinnell Prize Fund	420 00	Balance Jan 1, 1879	760 20
Totten Military Prize Fund	3 00		$729,885 51
	$729,885 51		

[1] A considerable part of the sum here charged as farm expenses includes also the labor of men and teams in building and repairing roads, grading and preparing the foundation of buildings, hauling gravel and stone, — work distinct from the cultivation of the farm.

DR. GEORGE MONTAGUE, *Treasurer, in Account with* MASSACHUSETTS AGRICULTURAL COLLEGE. CR.

1878.			1878.		
Jan. 1.	To Balance	$1,137 56		By Salaries for three quarters	$13,693 20
	Income of Hills Fund	322 75		Expenses Hills Fund Account	1,010 24
	State Endowment Fund	13,064 28		Contingent Account	2,707 82
	State Appropriation for Students' Labor	1,334 10		Botanical Account	1,628 65
	Mary Robinson Fund	35 00		Farm Account	2,574 64
	Prize Funds	180 00		Interest Account	1,381 66
	Totten Prize Fund	3 00		Prize Account	190 00
	Receipts from Students	3,052 45		Bills payable, Notes paid and renewed	3,000 00
	Farm Superintendent	1,506 78		Students' Bills, paid from Labor Fund	1,334 10
	Botanical Account	1,644 59	Dec. 31.		
	Bills payable, Notes for loans and renewal,	6,000 00		Balance	760 20
		$28,280 51			$28,280 51

Respectfully submitted,

GEO. MONTAGUE, *Treasurer.*

I have examined the Treasurer's accounts, and find them correctly stated, and accompanied by the proper vouchers.

HENRY COLT, *Auditor.*

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SUMMARY

OF

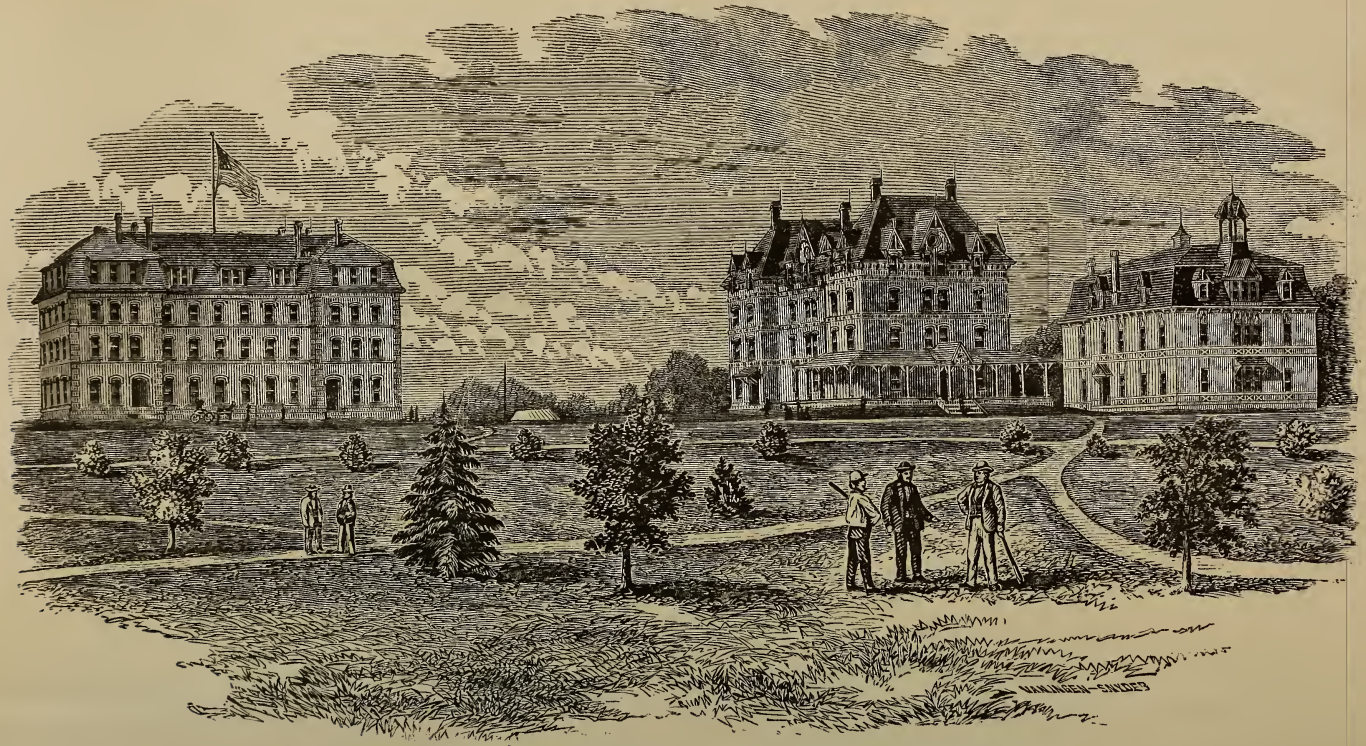
METEOROLOGICAL OBSERVATIONS FOR THE YEAR 1878.

TAKEN AT AMHERST, MASS., BY MISS SABRA C. SNELL.

LATITUDE, 42° 22′ 17″. LONGITUDE, 72° 34′ 30″. ELEVATION ABOVE THE SEA LEVEL, 267 FEET.

Summary of Meteorological Observations for 1878.

MONTH.	THERMOMETER IN OPEN AIR.			Amount of Rain or Melted Snow in gauge, in inches.	Depth of Snow, in inches.	Mean per cent of Sky.	WINDS PER CENT OF TIME AND FORCE.				BAROMETER HEIGHT REDUCED TO FREEZING POINT.			FORCE OR PRESSURE OF VAPOR, in inches.			RELATIVE HUMIDITY OR FRACTION OF SATURATION.		
	Max.	Min.	Mean.				N.W.	S.W.	S.E.	N.E.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
January .	44.4	-12.5	25.29	3.575	6 0	5.1	63	12	12	13	30.374	28.831	29.742	.252	.012	.126	100	36	71
February .	50.3	-3.2	27.14	3 665	13.5	4.6	57	16	9	18	29.968	29.199	29.666	.216	.025	.114	100	22	71
March .	65.1	13.2	39.24	2.565	–	5.4	61	20	9	10	30.203	28.764	29.654	.335	.050	.166	98	24	68
April .	73.1	37.0	52.17	5 853	–	7.4	35	23	36	6	30 006	28.927	29.569	.522	.149	.282	100	26	71
May . .	83.2	40.5	57.38	2 360	–	5.4	58	37	30	6	30.001	29.237	29.633	.613	.135	.318	94	25	69
June . .	90.2	46.4	64.73	6 003	–	4.5	41	30	25	4	29 980	29 250	29.661	.774	.168	.448	99	29	75
July . .	92.2	55.2	73.33	2 163	–	4.2	32	38	27	3	29.944	29.241	29.674	.900	.174	.599	99	35	83
August .	82.2	49.9	68.63	6.974	–	5.3	35	29	36	0	29.925	29.286	29.625	.914	.325	.577	100	41	83
September	84.5	38.0	63 20	2.821	–	5 0	31	24	37	8	30.220	29.465	29.871	.863	.136	.491	100	39	84
October .	77.3	27.0	54.43	2 054	–	5.2	47	22	27	4	30.067	29.194	29.737	.555	.091	.308	100	11	70
November.	57.2	19 8	39.11	5.339	–	7.3	59	15	16	10	30.219	28.732	29.653	.325	.047	.166	100	13	67
December.	53.7	11.7	28.95	6.020	9.0	5.6	59	27	12	2	30.176	28.641	29.657	.423	.006	.120	97	3	69
Year . .	92.2	-12.5	49.47	49.392	28.5	5.4	48	23	22	7	30.374	28.641	29.678	.914	.006	.309	100	3	72



MASSACHUSETTS AGRICULTURAL COLLEGE, AMHERST, MASS.